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Recent Developments in Cushion Hitches for Farm Tractors — *A. W. Clyde*

How to Get Better Lightning Protection for Farm Structures — *R. D. Bienemann*

Runoff and Soil Loss Measurements by Cropping Periods — *J. R. Carreker and A. P. Barnett*

Factors Affecting Operating Stability of Wheel Tractors (Part II) — *W. H. Worthington*

Mechanical Equipment for Unloading Chopped Forage — *W. R. Peterson*

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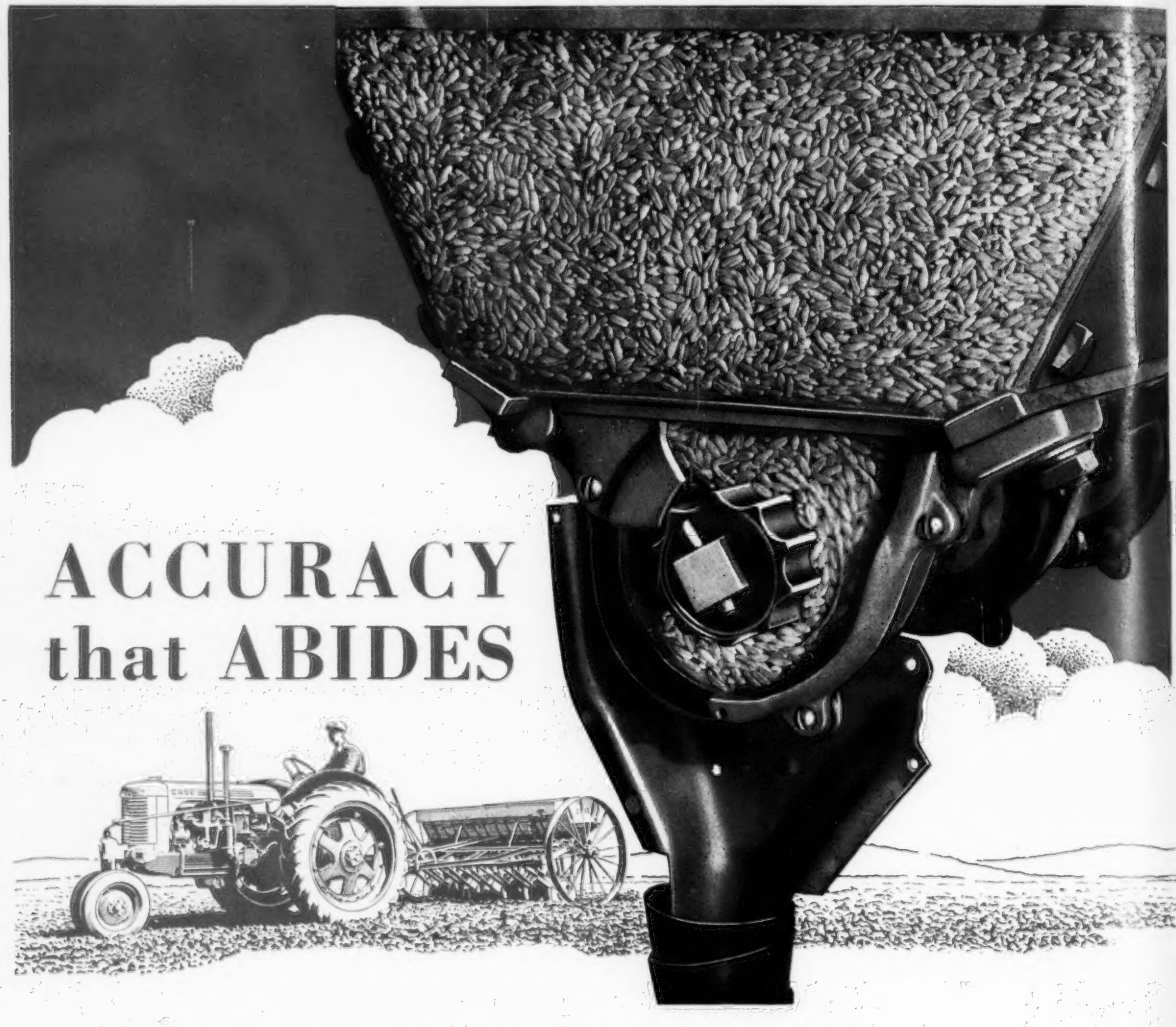

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EDITORIAL

Research Pays

AN INDICATION of the extent to which agricultural engineers are winning friends and influencing progress is seen in "The Payoff in Research," a recent publication by the Engineering College Research Council of the American Society for Engineering Education.

The booklet shows by example in 12 case histories some ways in which pure science research, to improve the technical foundation of engineering, incidentally produces byproduct cash values which more than cover its full cost.

It seems particularly significant that in selecting 12 examples from all of the technical branches of engineering represented in the work of the 73 institutional members of the Council, the editors used three examples from research in agricultural engineering. They deal with tractor testing, sugar beet mechanization, and flax handling machinery.

We note also that the Nebraska Tractor Tests, cited as a "standard of the world," are given more space in the booklet than any other one example. Brief direct quotations from five well-known agricultural engineers are included in the publication, and three others are mentioned by name.

This is generous and gratifying credit to agricultural engineers, and to agricultural engineering as a field in which new technical knowledge often finds early application in the public interest. It should provide inspiration, encouragement, and support for the application of our best analytical thought and investigation to many of the remaining physical problems of agriculture.

Nebraska Test Values

SOME interesting inferences may be drawn from the recently published bulletin and summary of the Nebraska Tractor Tests for the 29 years from 1920 through 1948.

An upward trend in drawbar horsepower-hours per gallon of fuel reflects the improvement in power generation and transmission efficiencies which might reasonably be expected as a result of engineering refinement through the years.

The fact that some makes and models manufactured and tested in 1937 or earlier are still in production may mean one or both of two things. They may have been of such advanced design at the time of their introduction that there has been little call for major design changes. At any rate they have stood up under the final test of farm use over a period of years. Also, the war and various other factors may have delayed the time when those particular models might otherwise have been superseded.

It would seem that the 84 reported tests on nearly as many models still in production by 13 manufacturers would give all farmers in the United States an adequate selection from which to purchase to meet their particular requirements. A possible exception is the small garden tractor.

What about the dozen or more makes of four-wheel tractors, at least one new make of track-type tractor, and more than three score garden tractors actively in the farm market, which have not yet passed the Nebraska tests? Some of them may have failed to make the grade. Some may have applications on file and be awaiting a test date. Many have never been submitted for test.

Granting that the Nebraska tests may not cover all of the factors influencing farm tractor value, they provide an impartial index to sound engineering and reliability. This index has proven generally adequate and satisfactory. It has been of great value, not only to farmers throughout the whole country, but to manufacturers honestly trying to provide good tractor values in competition with wildcat manufacturers, extravagant claims, and high-pressure selling.

The war and postwar heyday of ready sale for anything faintly resembling a tractor has passed, thanks to the increasing supply of performance tested models. Manufacturers attracted primarily by the peak demand may well be advised to either salvage what they can of their investment by getting out of this field while there is still time, or prepare to measure up to the Nebraska standard for farm tractors, in their product engineering, manufacture, advertising, sales, and service.

Uniform Plumbing Code

IT HAS come to our attention that farm requirements are receiving consideration in the progress being made toward the development of a Uniform Plumbing Code. In fact, it appears probable that a separate section applying to rural areas will be incorporated in the Code.

Codes have admitted disadvantages. They are hard to keep up to date and consistent with technical progress in their field. It is difficult to provide for their impartial administration and common-sense application to serve their intended purposes. A code which prescribes anything less than the best practice may encourage a false sense of security, and a code which prescribes the best may place the cost of installations in its field beyond the reach of those in greatest need of improved facilities.

Still, a rural plumbing code could be a big help to manufacturers, dealers, the building and plumbing trades, and farmers, in bringing about some closer agreement on minimum standards, on logical steps of progressive improvement on individual farms, and on product and installation features worth their cost under a variety of rural conditions.

A rural plumbing code will be drawn up by men personally used to modern sanitary facilities. Some of them are apt to forget that, for many rural residents, immediate installations up to modern urban standards are out of the question. Their choice is between some small, partially satisfactory steps toward better sanitation, or no improvement. Few of the farm families with the greatest sanitation hazards are going to spend a thousand dollars or more to change to porcelain and tile bathrooms in pastel colors, in one big step from a rain barrel, cistern, or open-well water supply; wash tub bathing; sinkhole, cesspool, or open stream drainage; and the reading room for old mail-order catalogs. Many agricultural engineers are close enough to farming and rural living conditions to provide effective reminders of this fact whenever and wherever the occasion may arise.

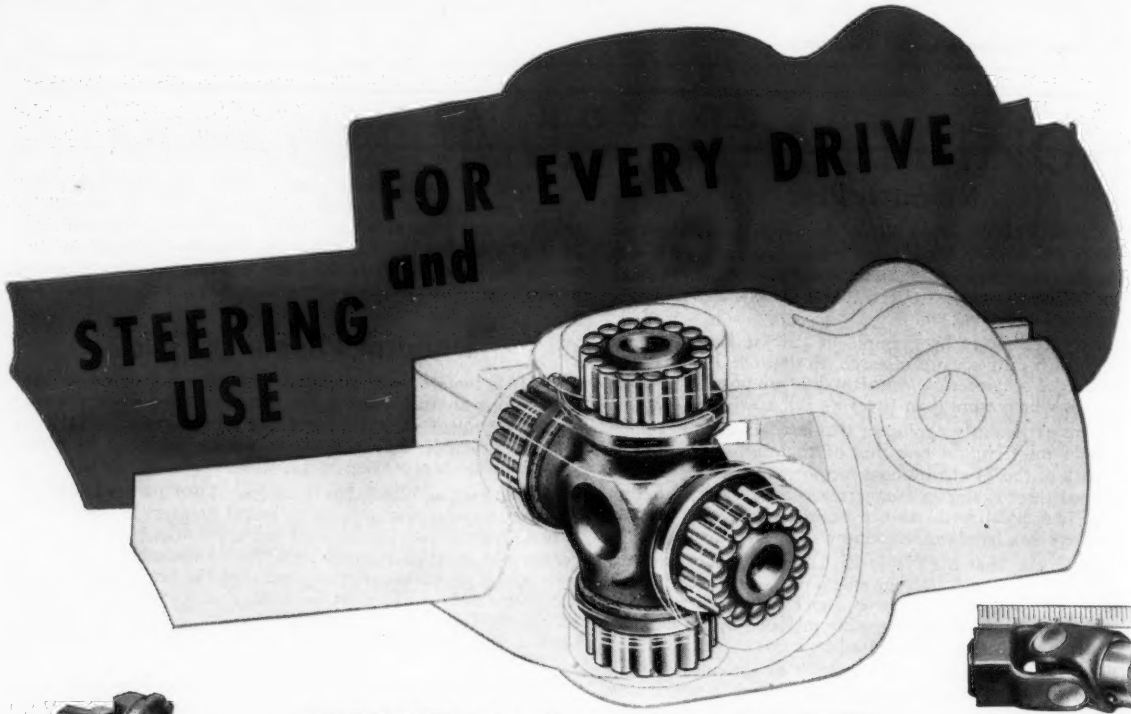
It will be a credit and a long-range personal advantage to all concerned to remember that the object of a rural plumbing code is not to stimulate sales of any particular class of products; nor to fix arbitrary standards as to who can properly do rural plumbing work; nor even to set up theoretical ideals of rural plumbing practice. Its one prime purpose should be to expedite the step-by-step improvement of rural sanitation.

Improving Advice to Farmers

HOW effectively are agricultural engineering principles of efficient and otherwise good operating practice being presented to farmers? To get an idea, take a second look at some of the pictures in most any current farm paper which makes a business of instructing and advising farmers.

We did that recently and found much that was good, along with some surprising errors, omissions, out-of-date ideas, and optical illusions. The pictures were apparently selected with a singleness of purpose that overlooked features which could easily prove misleading.

Among the editorial features, scenes on a farm good enough to warrant a special writeup included an apparently unsanitary and laborious practice in handling milk, and an atrociously hazardous woodpile. These were shown, not as things remaining to be improved, but as something to be copied by other farmers. *(Continued on page 192)*



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AGRICULTURAL ENGINEERING

VOL. 30 APRIL, 1949 NO. 4

Cushion Hitch Developments

By A. W. Clyde
FELLOW A.S.A.E.

DEVICES for stopping a tractor when the plow hits an obstacle have previously often been called stophitches. The farm equipment industry, however, seems to prefer the term "cushion hitch"; hence that term will be used here. Farmers in stony areas have long needed an adequate cushion hitch, and recently the application of hydraulic cylinders to plows has caused a revival of interest in such devices.

A previous paper[1] reported the progress in developing these devices up to 1942, and described several styles of hitches, including spring, hydraulic, and a combination of spring and hydraulic. It mentioned that results were sometimes better than was expected, particularly in preventing damage to cast shares. Tests since that time have indicated some of the reasons for this better performance, and suggestions for including such factors in design will be given later.

At the outset, the basic principles in stopping a moving weight should be reviewed. Kinetic energy is still the main cause of damage when a plow strikes an obstacle. It is just as real as any other form of energy. The size of force which a plowshare will stand is limited; therefore, an appreciable stopping distance is needed if the kinetic energy is to be absorbed without damage. Another source of pull on the plow in a quick stop is the tractive effort of the tractor, in case it is not declutched as soon as the impact occurs. In such a condition, anything that reduces traction is helpful, whether it be the limited traction of a light tractor on rubber tires, or a very low hitch point. Any reduction of traction, however, is only a help. At some speed the kinetic energy will be so great that the distance obtained by elasticity and other sources of yielding will be inadequate to keep the force within the safe limit. Some feeling seems to exist that rubber tires have reduced the need for cushioning. It is true that they may have reduced the tractive effort, but this is usually more than offset by greater weight and greater speed. To be effective in preventing plow damage, the rubber should be in the drawbar rather than on the wheels.

A few cushion hitches are in limited production now. The E. R. D. Mfg. Co., Stoughton, Wis., is reported to be making some. Pennsylvania State College has one of the prewar models, which was illustrated previously. It is a spring type with holding device and declutcher for certain tractors.

Fig. 1 shows a preloaded spring type made by the International Harvester Co. It has no holding device nor declutcher. The two springs are preloaded a total of 3260 lb, and their maximum is 5600 lb. I estimate the working extension (above the preload) as 3.3 in. James Morkoski, chief engineer of the company's Canton Ill., works, says this does not have as much capacity as might be desired and that other designs are being experimented with, including one that declutches the tractor and applies the brakes. It would seem that the capacity of the type shown in Fig. 1 could be increased by reducing the preload. A preload of 1800 lb would increase the capacity considerably.

Fig. 2 shows a cushion hitch made by the John Deere Plow Co. It has a holding device, A, for the normal pull, this consisting of cam surfaces held in contact by rubber springs. This hitch was first used without a declutcher, but is now furnished with a declutcher for certain John Deere tractors. The declutcher also applies the brake on the pulley, and hence on the drivewheels. The two springs in series give approximately 4¾-in movement with a force of 4450 lb. W. H. Silver of the John Deere Plow Works writes that the holding device has not been entirely satisfactory, its adjustment being critical. Protection is lost or reduced if the adjustment is too tight or too loose. If too loose, it may release without being noticed, with the result that the plow load deflects the springs and may reduce the capacity for shock absorption.

A hitch developed by John Deere to replace the one just

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1948, as a contribution of the Power and Machinery Division. Authorized for publication on January 10, 1949, as paper No. 1501 in the Journal Series of the Pennsylvania Agricultural Experiment Station.

A. W. CLYDE is professor of agricultural engineering, Pennsylvania State College, State College, Pa.

[1] Clyde, A. W. Tractor Stop-Hitches. AGRICULTURAL ENGINEERING, vol. 23, no. 1, p. 5 (January, 1942).

Fig. 1 Preloaded spring type of cushion hitch. Unless a declutcher is added, this type is unlikely to have enough capacity for common plowing speeds

Fig. 2 Spring type hitch with holding device at A for the normal pull. The holding device can be adjusted by a nut on the reverse side. A declutcher, not shown, has been used with this hitch to increase its effectiveness

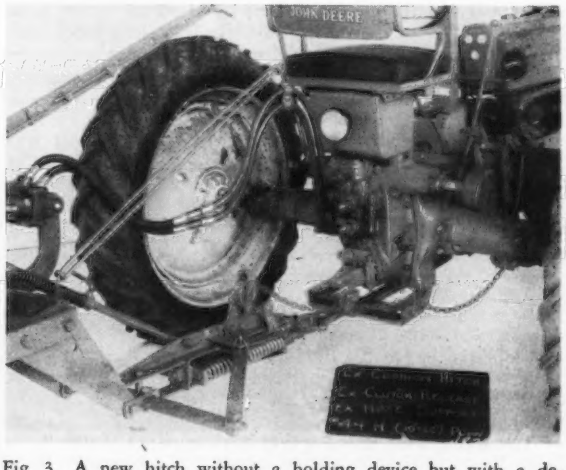


Fig. 3 A new hitch without a holding device but with a declutcher which also applies a brake on the tractor

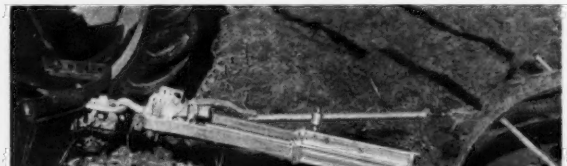


Fig. 4 A simple hydraulic hitch with tapered cylinder for giving approximately a uniform retarding force on the tractor as it slows down. An 11½-in extension is provided

described is shown in Fig. 3. It also declutches the tractor and brakes the pulley. No holding device is used, the normal load being taken by the springs. Three springs are used, one being in series with two. This gives 4⅞ in deflection with 5770 lb, and 1⅝ in additional with 11,550 lb. The combination is soft in the first three-quarters of the deflection, and then becomes very stiff in the remaining one-quarter. In my opinion, this spring arrangement gives considerable capacity which cannot be used, because plowshares will not stand such a large force, and few frogs and beams will stand it. Two of these springs in series would seem to give as much useable capacity as three in this arrangement, while all three in series would give much more useable capacity.

The hitch shown in Fig. 4 was described in the previous paper[1] and has now been used for several years at our institution. It is not being made commercially, but its performance has been such that it merits attention. It has no declutcher. A holding device carries the normal pull. When it releases, the tractor pulls against a piston. The orifice reduces in size as the tractor slows down, the object being to maintain a uniform resistance. The variable orifice is usually secured by having a taper bore in the cylinder. One characteristic of this type of hitch is that the resistance at any point of the movement depends on the speed of the piston at that instant. It has given excellent protection to two-bottom plows.

During the past summer I assisted the Allis-Chalmers Mfg. Co. in making tests on two styles of cushion hitches. These tests were made with the active participation of members of the engineering staff at La Crosse, Wis.: W. H. Tanke, W. G. Charley, and Robert Reaves. Neither hitch used a clutch throwout. One was a preloaded spring and the other was a novel hydraulic type with a holding device for the normal pull, and a pressure regulating valve for controlling the resistance of the hydraulic cylinder and piston.

The purpose of the tests was more than merely trying these individual hitches. A more important object was to get data needed for design, such as the maximum permissible force on shares and beams, the part played by elasticity of the plow beam and other parts, and if possible to learn how much tractive effort should be figured on from the tractor.

The obstacle was a block of steel 9x15x17 in, weighing 650 lb, which was sunk a little below the ground surface. To prevent it from being rolled out, it was held in place by four substantial stakes. In practically all trials, the tractor was timed over a measured distance just before the impact. The general method was to start at a low speed and then go to higher speeds until the plow was damaged.

With the spring hitch, the maximum force between tractor and plow was obtained by a pointer which showed maximum spring deflection, and with the hydraulic hitch it was obtained with a Brinnell device. This device consisted of a ⅜-in ball which was pressed into a piece of cold rolled steel ¼-in thick. The indentation was then measured with a Brinnell microscope and compared with that produced by known forces. Both of these indicators showed the force between the tractor and the plow. The force on the share may have been larger because of the plow's inertia.

The spring used in the spring hitch required 10,000 lb. to close. It was preloaded to 1,300 lb, but the average plow draft exceeded that figure. The spring's deflection in normal work

Fig. 5 A novel hydraulic hitch with pressure-regulating valve which was tested the past season. It is shown in the unlatched and partly extended position

was observed in each trial so that calculations could be made on the average spring force and the spring movement following the impact.

The hydraulic hitch is shown in Fig. 5. A Holland release hitch carries the normal pull and releases when the obstacle is hit. The tractor continues forward, pulling against the 1¼-in piston. When sufficient pressure is developed, the spring-loaded valve opens, allowing oil to go into the reservoir. A piston movement of 10¼ in is provided. Ordinarily the tractor is stopped with wheels spinning in less than that distance. The operator declutches as soon as possible and backs up to recouple. The oil then returns through the check valve to the cylinder. Fluid and mechanical friction seem usually to give 500 to 700 lb resistance in this device, though the results on this point were rather scattered. This means that, if friction is neglected, the pressure-regulating spring should be adjusted so that the valve will start to open when the force on the piston is 500 to 700 lb less than the desired maximum.

The spring type of hitch performed satisfactorily when the speed was low enough to keep the maximum force at not over 5000 lb. After the preload was deducted, however, the spring used had very little capacity from that point up to 5000 lb. By this is meant that the average spring force used in stopping the tractor, multiplied by its movement in stopping, was rather low. The performance of the hydraulic hitch was very encouraging. It had much more capacity for absorbing energy than the spring type. With a tractor and operator weighing 4350 lb going down a grade of approximately 10 percent, several strikes were made at nearly 4 mph without damaging soft-center steel shares and two strikes were made at over 4 mph without damage. Protection at this higher speed was not always furnished, however.

The interpretation of these and other tests is a difficult matter because of the variability that enters into them. The speed at the instant of impact may not be known very exactly, the actual tractive effort of the tractor after the impact is somewhat uncertain, and the distance contributed by elasticity of the parts, displacement of the plow, and movement of the obstacle are hard to get accurately. I am venturing an interpretation, however, for two-bottom trailing plows pulled by rubber-tired tractors. It is believed that a high degree of protection will be furnished to soft-center steel shares, to some makes of solid steel shares, and to some cast iron shares if the method of design outlined below is followed.

Based on the fact that the work done in stopping is equal to the kinetic energy of the tractor plus the work done by traction plus the work added by going down hill, an approximate equation may be made for hitches which do not declutch the tractor, as follows:

$$(H+R)d = 0.4WS^2 + Td + .01Wfd$$

$$\text{or } d = \frac{0.4WS^2}{H + R - T - .01Wf} \qquad [1]$$

in which

H = average force between plow and tractor, lb
R = rolling resistance of tractor, lb
W = weight of tractor and operator, lb
d = total stopping distance, in
S = speed, mph
T = tractive effort following impact, lb
f = slope of ground, feet per 100 ft

This equation assumes that the energy of the plow will be absorbed by the soil's resistance and the movement or elasticity of the plow. It is believed the *maximum* value of the force between the plow and tractor should not exceed 5000 lb for good protection. T will probably seldom exceed 2000 lb for a 4200-lb value of W, at least with general-purpose tractors having a high center of gravity. I believe that, in a sudden stop, the inertia of the tractor reduces the ground reaction on the drivewheels and hence makes T less than the normal maximum tractive effort. Previous experiments with Allis-Chalmers had shown that more than one inch deflection occurs in the plow beam alone. Additional distance is also added by the elasticity of other parts, by tipping or side movement of the plow and often by yielding of the obstacle. Summing these up, a total of 2 in can usually be counted on from these sources, this being in addition to the movement or distance provided in the hitch. In other words, it is suggested that the extension needed in the hitch is 2 in less than d in the formula.

A similar formula for hitches which declutch the tractor at the instant of impact is

$$(H + R)\, d = .04WS^2 + K + .01\, Wfd$$

$$\text{or } d = \frac{0.4WS^2 + K}{H + R - .01Wf} \qquad [2]$$

The symbols are the same as in equation (1). K is the kinetic energy, in inch-pounds, added by revolving parts. For rubber tires it may be approximated as 10 percent of $0.4WS^2$. $K \div d$ cannot exceed T, because the wheels can spin when T is reached.

For the same capacity, the hydraulic hitch has a basic advantage over the spring in that it needs less stopping distance or extension. The strength of the plowshare usually limits the force that can be put on the plow. The hydraulic hitch can be made to furnish approximately a uniform force which may be near the limit. A spring, however, starts at zero or some relatively low force and goes up to the maximum permissible. Its average force is therefore lower than that of the hydraulic hitch, and the distance must be greater to provide the same capacity. This fact favors the hydraulic hitch, particularly on mounted plows, where a short distance may be greatly desired.

Whether to include a declutcher or not is a question that each designer will have to decide for himself. It reduces the demand on the cushion hitch, but adds to the complication, interferes with interchanging tractors and plows, and may or may not add to the cost. Good protection for one and 2-bottom plows with steel shares can be secured without a declutcher. For heavier tractors and wider plows, a declutcher may be a practical necessity. About the same thing may be said of applying brakes.

Following is a comparison based on equations [1] and [2] for four hitches for a 4000-lb tractor, 3½ mph, down a 5 percent grade. The maximum force on the plow is limited to 5000 lb, T is 1800 lb, and R is 200 lb. The hitch types are:

1 Hydraulic with holding device
2 Spring with 1500-lb preload
3 Spring with 1500-lb preload and declutcher
4 Spring with holding device, no preload, with declutcher.

	Type of Hitch			
	1	2	3	4
Extension needed, d — 2 in	4⅛	11½	4⅜	6⅝
Approx. weight of spring, lb*		73†	33†	33

* Based on maximum stress of 110,000 psi and k factor of 1.22.

† If the 1500-lb preload is not enough for the draft peaks, then more extension and more pounds of spring will be needed.

CONCLUSIONS

1 Farmers in stony areas have long needed adequate plow protection without the delay and inconvenience of the ordinary release. Rubber tires increased their need for it and now the use of hydraulic control brings a still greater need. I believe that enough people will buy an adequate device to justify its manufacture.

2 The effectiveness of a cushion hitch is measured by its capacity for absorbing energy. This is expressed in inch-pounds (or foot-pounds) and is the product of the average force and the distance the hitch will extend. The capacity needed depends on whether the tractor is declutched and whether brakes are applied, as well as on weight, speed, etc.

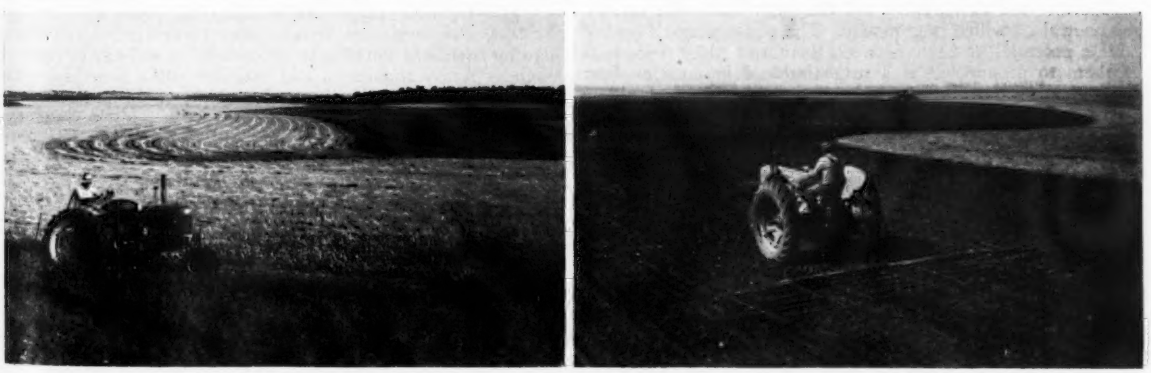
3 Progress has been made in the design of cushion hitches. With present information on trailing plows, it seems fairly safe to count on two inches of distance in addition to that built into the hitch. It also seems fairly certain that the tractive effort immediately after impact is less than the maximum effort because the loading of the drive wheels is usually reduced.

4 A spring type hitch is not likely to be given enough capacity for present speeds with more than one plow unless a declutcher is included. The number of pounds of spring required for adequate protection is so great that most designers consider it impracticable.

5 The hydraulic type of hitch has the advantage that it can be made to give nearly a uniform stopping force. For this reason, it can have much more capacity for a given extension than a spring. This may make it possible to omit the declutcher with the hydraulic hitch.

6 The simple hydraulic hitch with a tapered cylinder or with throttling bars, and without a declutcher, has had much use at the Pennsylvania Agricultural Experiment Station and has given good protection to steel shares. The protection with cast shares is not 100 per cent, but has been better than was expected.

7 The hydraulic hitch with pressure regulating valve has given excellent results in tests. Its resistance is nearly constant, regardless of speed. The cost appears to be not excessive, and this style should have further study and testing.



These pictures, by courtesy of the J. I. Case Co., in addition to showing applications of Case power-farming equipment, also present fine examples of farming on the contour

Lightning Protection for Farm Structures

By R. D. Bienemann

MEMBER A.S.A.E

IT IS alarming to know that, although many thousands of buildings are protected against lightning, it still is the prime cause of farm fires. According to the record of the National Board of Fire Underwriters' in 1947, it headed the list with 37 per cent, more than three times the next closest cause, "chimneys, flues, cupolas, stacks, etc.," with 11 per cent. This is an alarming increase, when we look at the record for the year previous which showed lightning as the leading cause of farm fires, but with only 31 per cent of the total. Adequate means of lightning protection was unavailable during the war years due to restrictions on the use of strategic metals. We are now paying the price.

At a meeting of the Committee on Farm Fire Protection of the National Fire Protection Association in Chicago, late in 1948 it was pointed out that the 1947 total farm fire loss showed an increase of 24 per cent over 1946, and 1948 up to that time showed an increase of approximately 4 per cent over 1947. Taking the 6 per cent increase in lightning losses for 1947 over 1946 on the basis of the over-all increase in farm fires during this period, the total is much more alarming. Using the figures of $80,000,000 for 1946, 31 per cent of the total farm fire loss would be $24,800,000, and for 1947, 37 per cent of the total farm fire loss would be $37,000,000 an increase of $12,200,000 in just one year, or approximately a 50 per cent increase in the total dollars and cents loss by lightning. Was it economy to eliminate the installation and maintenance of lightning protection for the period of war years? The loss ratio prior to 1941 had been brought down to approximately 20 per cent on a ten-year average.

We cannot charge the entire loss increase to the elimination of lightning protection alone for the period of the war years, for as man progresses, he increases his hazards. Just prior to the war, and even during the war years, we were working feverishly to supply a great many more farmers with the convenience of electricity both for their homes and utility buildings. Farm mechanization was foremost in our minds to cut operating time and enable the farmer to do more work with less labor, and along with it came the increased hazards.

Our company in its close contacts with the farm recognized these increased hazards and began an immediate study leading to their elimination. In working with one small farm mutual, it was discovered that 70 per cent of their total losses was by lightning, 69 per cent of which was due to lightning surges following electrical wires into buildings. This was one phase of lightning with which an ordinary lightning protection system could not cope. It was not direct lightning but a follow-through on the wiring. This is induced or "secondary" lightning, and its only connection with the lightning we see is by induction of a surge into the electrical wiring.

Most of our farms today use 120-240-v three-wire service, the neutral of which is grounded. The phase wires X and Y have a potential of 240 v between them and 120 v from each of them to ground. It is a surge induced into these phase wires X and Y, having no ready discharge path and building up to sufficient potential to flash over to ground, which is directly responsible for secondary lightning damage.

Discharge of this induced surge is seldom if ever powerful enough in itself to do any serious damage. Where it has current enough to ionize a path through the air of sufficiently low resistance for 120 v to follow, the resultant damage is quite commonly attributed directly to lightning. Actually the discharge path is set up by secondary lightning, and the damage is done by power following from X or Y to ground. Power in this flash to ground is limited only by fuse capacity, and in the case of ranges and large motors this will be from 45 to 100 amp. At 120 v this is a sizeable quantity of power, ample to do considerable damage and in some cases start fires.

All that is necessary to prevent damage from secondary lightning is to provide a suitable discharge path to ground from the phase wires X and Y for the surges induced into them by direct discharges between cloud and earth. This type of discharge causes an instant collapse of an electrostatic field which covers a considerable area. Theoretically this field extends to infinity, but experience suggests that most secondary lightning damage occurs within a three-mile radius from the parent discharge. Visualize this electrostatic field as a growing mountain, building from the earth towards the cloud, and another of opposite polarity building from the cloud down. As these two peaks approach, their static potential is increased steadily, until finally it exceeds the insulating value of the atmosphere separating them, and the resulting discharge is what we see as lightning. At the time of discharge, the collapse of this electrostatic field instantly subjects every piece of metal within its scope to an induced potential, of opposite polarity from that in the earth.

On the basis of 20,000 v per in through dry air, induced surges have been known to attain a potential of as much as 5,000 v. This greatly exceeds the insulation value of house wiring and appliances in the average home. Fortunately the balances between voltage, resistance, and current as stated in Ohm's Law apply here also. Therefore, in most cases the induced voltage does not exceed insulation value of the house wiring or appliances and no damage is done. Many times when it does exceed insulation values and flashes over to ground, there is not enough current in the discharge to ionize a path through the air to such an extent that the 120-v power will follow. Possibly you have heard this spitting or snapping in your house wiring during a lightning storm.

Secondary lightning damage has been more prevalent with increased rural electrification during the past two decades. Overhead wiring from the house to outbuildings is a common source of this trouble. Placing the neutral on top in an horizontal run, as is common practice today, helps by shielding the two phases, wires X and Y, but this is only a partial remedy, and by no means a cure. Arresters for protection of low-voltage wiring have been used for several years with varied success. We feel after several years of research in this field that limited success of these devices was due primarily to two factors, namely, the lag in operation of pellet-type arresters and the unusually low insulation level at which they must operate.

The value of capacitors in lightning protection of low-voltage, low-insulation circuits was recognized many years ago by engineers working on protection for railway equipment such as rotary convertors and 500 and 600-v generators. At that time there was little need for household protection of this type. The first conduit installations were a scant ten years old, electric refrigerators and ranges were new and scarce, and there were no plug-in radios. Compare that with the situation today and the need for adequate protection against secondary lightning becomes apparent.

In 1940 a few test installations of capacitors were made, in homes that had been damaged severely and repeatedly by secondary lightning. Several more were made in 1941. Ordinary paper condensers were used with 100 per cent success, as long as the condensers lasted. During 1941 a special unit consisting of two condensers (one from each phase wire X and Y to ground) was designed for this purpose. Effectiveness of this unit was complete within its range, but during the following five years a few failures indicated that the unit was not rugged enough to stand up *(Continued on page 176)*

Abstract of a paper presented at a meeting of the Southeast Section of the American Society of Agricultural Engineers at Baton Rouge, La., February, 1949. It supplements an earlier paper, entitled "Safe Lightning Protection", by the author, published in AGRICULTURAL ENGINEERING for November, 1947.

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Runoff and Soil Loss Measurements by Cropping Periods

By John R. Carreker and Aurelius P. Barnett
MEMBER A.S.A.E. JUNIOR MEMBER A.S.A.E.

THIS paper reports data collected on runoff and erosion since 1940 at the Southern Piedmont Conservation Experiment Station of the USDA Soil Conservation Service at Watkinsville, Georgia.

It is customary to report *annual* soil and water losses as measured from runoff plots. A further breakdown into *seasonal* losses has been useful to indicate at what seasons of the year erosion control measures are most needed. Continuous cotton plot soil and water loss data have been most useful for supplying these findings. An important finding has been that three-fourths of the annual soil and water loss comes in the spring and summer.

Accordingly research conservationists have tested many rotations designed to furnish land protection when it is most needed—during the main spring and summer growing season. However, it usually happens that in these rotations the cover crops or their stubbles and residues occupy the fields for extended periods over some or all seasons of the year, whereas the row crops are usually on the land no longer than 6 or 7 months.

The purpose of this paper is principally to evaluate the protection furnished by several of these crops of both types *by cropping periods,* rather than by uniform calendar periods.

Runoff and erosion control investigations have been conducted at various experiment stations throughout the United States for a number of years. Articles and reports in various form have been published from many of the stations.

A brief study of these reports from those locations in the South and Southwest is of interest to southern agricultural workers. The reports disclose several outstanding facts, among which are the following:

1 Soil losses from row-cropped land increase rapidly with increases in land slope.

2 Adequate terraces markedly reduce the quantity of soil that is lost from a field.

3 Rotations of close-growing crops and row crops reduce runoff and erosion on sloping land.

4 Well-established sod crops give effective runoff and erosion control, even on very steep slopes.

Runoff and soil loss investigations were begun at the Southern Piedmont Conservation Experiment Station, Watkinsville, Ga., in 1938. Plots representing approximate terrace interval slope lengths were established on land slopes of 3, 7, and 11 per cent, representing capability Classes II, III and IV, respectively. All plots were 20.74 ft wide. Their lengths were 105, 70, and 35 ft, with areas of 1/20, 1/30 and 1/60 acre, respectively, on the 3, 7, and 11 per cent slopes. The soils on these respective slopes were sandy loam, sandy clay loam, and clay loam of the Cecil series. These surface textures indicate the degree to which erosion has progressed during past years of cultivation.

Crop rotation studies were conducted on these runoff plots to measure the effectiveness of cropping practices for controlling runoff and erosion at the source area between terraces. The soil and water loss data presented in this paper therefore apply to the terrace interval areas. Continuous cotton was used as a check on all slopes.

The relationships between land slope and runoff and erosion from continuous cotton are shown in Table 1.

TABLE 1. Average Annual Runoff and Soil Loss from Continuous Cotton on 3, 7, and 11 Per Cent Slopes, with Lengths at 105, 70, and 35-ft, Respectively, for the 1940-47 8-yr Period at Watkinsville, Ga.

LAND SLOPE PERCENT	SLOPE LENGTH FEET	RAINFALL INCHES	RUNOFF INCHES	SOIL LOSS TONS PER ACRE
3	105	50.40	8.66	4.45
7	70	51.15	10.90	24.95
11	35	49.70	10.83	22.78

The average annual runoff was 8.66 in on 3 per cent slope and 10.90 and 10.83 in on the 7 and 11 per cent slopes, respectively. The low soil loss of 4.45 tons per acre on the 3 per cent slope indicates that good terracing and contour cultivation give fairly effective erosion control on this gentle slope.

The 25 tons per acre soil loss on the 7 per cent slope indicates that terracing and contour culture give inadequate protection from erosion on that slope. Protective cropping practices in addition to terracing and contour culture are needed here.

There was a reduction in erosion from 24.95 tons per acre on the 7 per cent slope to 22.78 tons per acre on the 11 per cent slope. This result reflects principally the potent effect of cutting the slope length in half, even though the slope was steeper. The rate of erosion per unit of slope length was much greater on these steeper plots. Past erosion was so rapid on the 11 per cent slope that we have no topsoil left on the land. This clearly indicates the future condition of the land with 7 per cent slope if the erosion is allowed to go unchecked.

The season of the year in which erosion is most likely to occur is of primary importance in adapting cropping practices for its control.

SEASONAL AVERAGES ON 7 PER CENT SLOPE

Season	Months	Rainfall, in	Runoff, in	Soil Loss tons/acre
Winter	December, January, February	15.18	3.18	4.23
Spring	March, April, May	13.95	2.37	6.53
Summer	June, July, August	13.69	3.70	12.90
Fall	September, October, November	8.33	1.65	1.29

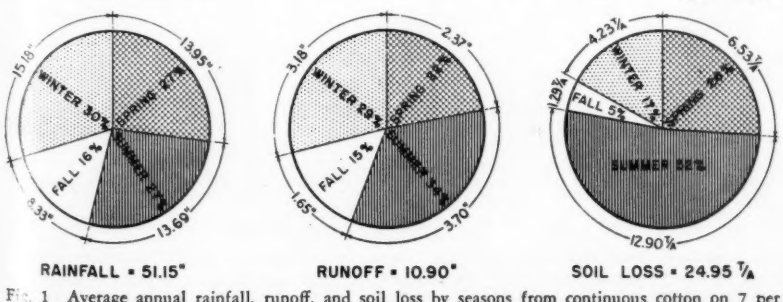


Fig. 1 Average annual rainfall, runoff, and soil loss by seasons from continuous cotton on 7 per cent, 70-ft length of slope, Cecil sandy clay loam, land class III, for the 8-yr period, 1940-47

The averages for rainfall, runoff, and soil loss by seasons on the land in continuous cotton on 7 per cent slope are for the 8-yr period.

These relationships are also shown graphically in Fig. 1.

The rates and distribution of rainfall vary from season to season and from one year to the next. Erosion varies accordingly. The seasonal losses given in the foregoing table and in Fig. 1 were obtained under these varying rainfall conditions and reflect what we might expect over a period of years.

This paper was presented at a meeting of the Southeast Section of the American Society of Agricultural Engineers at Baton Rouge, La., February, 1949.

JOHN R. CARREKER and AURELIUS P. BARNETT are agricultural engineers (research) Soil Conservation Service, U. S. Department of Agriculture (Watkinsville, Ga.).

The variation in annual erosion from year to year is shown in Fig. 2 for the continuous cotton on the 7 per cent slope land.

The foregoing discussion deals with runoff and erosion from land in continuous cotton, a practice that affords little ground cover the year around. Cropping practices that include close-growing crops at least part of the time are indicated for sloping land.

Average annual runoff and soil loss data from several cropping practices with varying degrees of ground cover are given in Table 2.

Sufficient plots were available so that each crop in the different rotations reported in this paper was on the ground each year of record. For example, in the 2-yr rotation of cotton-vetch, corn-crotalaria, there was a plot of cotton and one of corn each year. Therefore, during the 1943-47 6-yr period, 6-yr of records from both cotton and corn as well as from the check condition of continuous cotton were obtained.

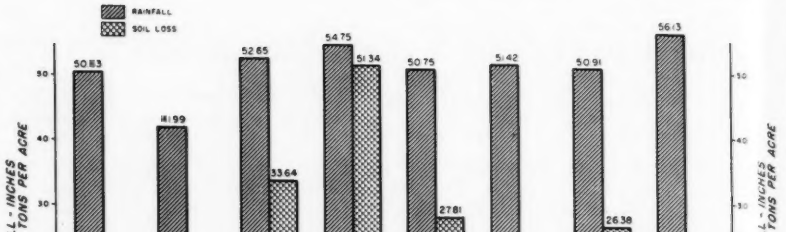


Fig. 2 Rainfall and soil loss by years from continuous cotton on 7 per cent, 70-ft length of slope, Cecil clay loam, land class III

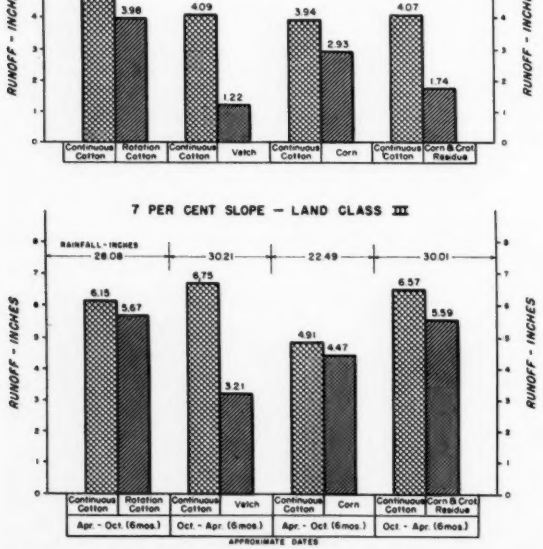
TABLE 2. Average Annual Runoff and Soil Losses from Specific Cropping Practices on 3, 7 and 11-Per Cent Slopes of 105, 70 and 35 ft Length, Respectively

CROPPING PRACTICE	LAND SLOPE					
	3%		7%		11%	
	RUNOFF INCHES	SOIL LOSS TONS / AC.	RUNOFF INCHES	SOIL LOSS TONS / AC.	RUNOFF INCHES	SOIL LOSS TONS / AC.
Continuous Cotton (1940-47)	8.66	4.45	10.90	24.95	10.83	22.78
2-Year Rotation (1943-47)						
(1) Corn - Crotalaria	5.16	3.12	10.40	14.86		
(2) Cotton-Vetch	6.30	2.87	9.13	15.82		
3-Year Rotation (1942-47)						
(1) Oats-Kobe Lespedeza			5.92	2.83	10.74	9.20
(2) Kobe Lespedeza			5.35	0.24	8.26	1.78
(3) Cotton			6.26	7.08	7.93*	8.70*
3-Year Rotation (1944-47)						
(1) Kudzu					3.98	1.09
(2) Kudzu					2.21	0.17
(3) Corn					3.43	1.06
Sericea Lespedeza (1943-47)					3.65	0.40

* Corn was used in the 3-yr rotation on the 11 per cent slope.
NOTE: Average annual rainfall = 50.40 in.

The 2-yr rotation of cotton and corn with vetch and crotalaria reduced both the runoff and erosion on the 3 and 7 per cent slopes by similar proportions, as compared to the losses from continuous cotton on these respective slopes. The resulting erosion loss on the 3 per cent slope is considered satisfactorily diminished, but erosion on the 7 per cent slope continued too high. A cropping practice that is more protective than this rotation with continuous row-cropping and interplanted legumes is needed for moderately and steeply sloping land.

Somewhat similar results were obtained with the 3-yr rotation of oats-lespedeza, volunteer lespedeza, and cotton or corn on the 7 and 11 per cent slopes. Runoff and erosion reductions were adequate on the 7 per cent slope but not on the 11 per cent slope. Here again is illustrated the need for a more effective cropping practice as the slope becomes greater.



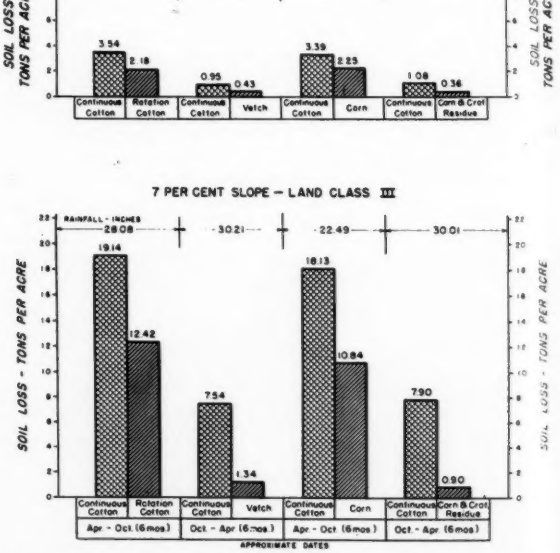


Fig. 3 (*Left*) Runoff by cropping periods from continuous cotton and a 2-yr rotation of (1) cotton-vetch and (2) corn-crotalaria on 3 and 7 per cent slope land, with 105 and 70-ft length of slope, respectively. Years of record, 1943-48 • Fig. 4 (*Right*) Soil loss by cropping periods from continuous cotton and a 2-yr rotation of (1) cotton-vetch and (2) corn-crotalaria on 3 and 7 per cent slope land, with 105 and 70-ft length of slope, respectively. Years of record, 1943-48

Satisfactory results were obtained with sericea lespedeza and with the rotation of kudzu, kudzu and corn, on the 11 per cent slope. The results are the more striking because the plots with this kudzu rotation were 70 ft in length instead of 35 ft as for all the other crops on 11 per cent slopes.

These data in Table 2 are presented as average annual figures. But the cropping practices do not change at the end of the calendar year as these data would seem to indicate.

This pattern of reporting average annual runoff and soil losses was the method used in nearly all the reports cited in the bibliography. However, Borst, McCall, and Bell in the Zanesville, Ohio, report separated out the runoff and erosion losses for the 5 mo that corn was on the ground in the 4-yr rotation of corn, wheat, meadow, and meadow. They then compared these data to similar losses from continuous corn. They showed that even during the season of row-crop occupancy, there was a substantial reduction in both runoff and erosion from the corn in rotation as compared to the continuous corn. Also, Hickock, Mayer, and Kohnke showed that reporting runoff from small watersheds by crop-occupancy seasons gave a better comparison between crops than was obtained from reporting on an annual basis.

We have similarly analyzed the data from the Watkinsville Station, presented in Table 2, for the respective periods each crop occupied the land in the rotations cited. We find that this seasonal analysis presents a better answer to the question: "What effect does each crop in the rotation have on reducing runoff and erosion?"

The runoff and erosion from each crop was compared with continuous cotton for the exact period of time that each crop occupied the land in a given rotation. All of the crops in each rotation were on the ground in season each year.

Though the rainfall intensity varied from season to season, the respective crops under study were subjected to the same rainfall conditions as the continuous cotton for the periods cited. It is well known that weak cropping practices sometimes show up well when the milder erosive rains occur, but give way when under severe test. Good protective practices stand up.

We can best evaluate the protective abilities of various crops, therefore, by checking up on their actual performance on typical land and farm conditions over a period of years, when subjected to a wide variety of erosive storms.

The rainfall conditions experienced during this period of record included rains of various types of intensity, amount, and duration. The length of record is sufficient to be fairly indicative of the prevailing conditions, however.

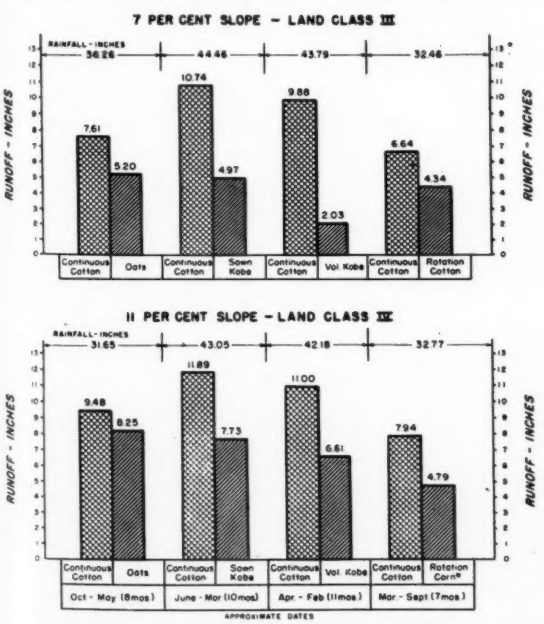
Excessive rate rains, as per Yarnell's definition, do not always cause high rates of runoff and erosion, even from land in continuous cotton. There has been no attempt in this paper to correlate the runoff and soil losses from either the continuous cotton or the crops in rotation with excessive rate rains. These relationships are too complex for the scope of this paper. Since the same rainfall conditions applied to all conditions within the stated periods, the results obtained are valid.

The 2-yr rotation of cotton-vetch, corn-crotalaria was broken into the periods of (1) cotton (from date of turning land to date vetch was planted), (2) vetch (planting date to turning date), (3) corn (date vetch was turned to date vetch was planted in cotton), and (4) corn-crotalaria residue (date vetch was planted in cotton to date corn-crotalaria residue was turned). These 4 periods cover 2 yr.

The average seasonal runoff from each of these conditions is shown in Fig. 3 for the 3 and 7 per cent slopes. Six years of records for each crop are included in these data. There was only a slight difference in the amount of runoff from the cotton or corn in rotation and from continuous cotton while the row crops occupied the land. Both the green cover of vetch and the dead cornstalks and crotalaria residue, however, were effective in reducing the quantity of runoff. The relative effectiveness of these two crops was greater on the 3 per cent slope than on the 7 per cent slope.

The average seasonal soil loss data from each of the component crops in this rotation, as compared to continuous cotton, are shown in Fig. 4. The erosion losses on the 3 per cent slope were not great from either the continuous cotton or the crops in the rotation.

Soil loss from the cotton rotation with 7 per cent slope was 12.42 tons per acre, as compared to 19.14 tons from land in continuous cotton. This was a reduction of only 35 per cent in the erosion losses during the high-loss summer period. The



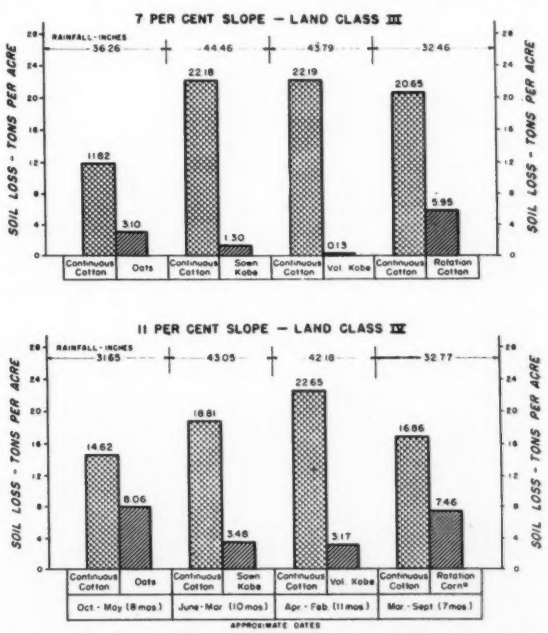


Fig. 5 (*Left*) Runoff by cropping periods from continuous cotton and a 3-yr rotation of (1) oats-sown Kobe lespedeza, (2) volunteer Kobe lespedeza, and (3) cotton on 7 per cent slope and corn (row crop changed to cotton in 1948) on 11 per cent slope land, with 70 and 35-ft length of slope, respectively. Years of record, 1941-48 for 7 per cent slope and 1943-48 for 11 per cent slope • Fig. 6 (*Right*) Soil loss by cropping periods from continuous cotton and a 3-yr rotation of (1) oats and sown Kobe lespedeza, (2) volunteer Kobe lespedeza, and (3) cotton on 7 per cent slope and corn (row crop changed to cotton in 1948) on 11 per cent slope land, with 70 and 35-ft length of slope, respectively. Years of record, 1941-48 for 7 per cent slope and 1943-48 for 11 per cent slope

soil loss from vetch was 1.34 tons per acre, as compared to 7.54 tons per acre from continuous cotton land while vetch was on the land in the rotation. This was a reduction of 82 per cent in erosion during the less severe winter period.

The soil loss from the corn land on the 7 per cent slope was 10.84 tons per acre, a little less than the erosion from cotton in rotation, and 40 per cent less than the 18.13 tons per acre from continuous cotton for the same period.

A light ground cover of cornstalks and dead crotalaria (early spectabalis) residue allowed even less erosion during the winter period than did vetch. The loss from this crop was 0.90 tons per acre, or 89 per cent less than that from continuous cotton for the same period.

These data show:

1 On the 3 per cent slope where the erosion hazard is small, this 2-yr rotation of two row crops with two legume crops gives adequate erosion control, assuming terraced land conditions.

2 The legume crops in this rotation on the 7 per cent slope give effective winter erosion control, but it breaks down during the summer period when row crops occupy the land.

3 The greatest erosion hazard is during the row-crop portion of the rotation.

The annual soil loss data in Table 1 indicate that the 3-yr rotation of (1) oats and sown Kobe lespedeza for seed, (2) volunteer Kobe lespedeza for seed, and (3) cotton does give adequate erosion control on land with 7 per cent slope. The degree of erosion control from this rotation, using corn for the row-crop year, on 11 per cent slope land was not good enough, however.

The runoff data for the individual cropping periods in this rotation are shown in Fig. 5. All crops in the rotation markedly reduced the runoff as compared to continuous cotton. The greatest reduction was with the volunteer lespedeza from April to February with 2.03 in of runoff as compared with 9.88 in of runoff during this same period on continuous cotton land.

Turning the lespedeza residue into the land for cotton did not destroy the beneficial protective effect of the lespedeza. There was only 4.34 in of runoff from the rotation cotton while 6.64 in ran off the continuous cotton land.

The runoff relationship between the rotation crops and the continuous cotton on land with 11 per cent slope was fairly similar to those on the 7 per cent land. The runoff was higher, however, from all crops on the 11 per cent slope.

The relative erosion-control effectiveness of the four crop conditions in the rotation is shown in Fig. 6. The Kobe lespedeza did an effective job of erosion control its first year and gave almost complete control the second year on both 7 and 11 per cent slopes. The erosion from oats on the land with 7 per cent slope was 3.10 tons per acre, or 74 per cent below the 11.82 tons per acre from the continuous cotton. Comparable losses on 11 per cent slope were 8.06 tons per acre from the oats and 14.62 tons per acre from continuous cotton. Here the oats were only 45 per cent effective in reducing erosion.

The erosion from the cotton in rotation on 7 per cent slope was 5.95 tons per acre, or 71 per cent less than the 20.65 tons on continuous cotton. On the 11 per cent slope, the erosion from the corn in rotation was 7.46 tons per acre, which was only 56 per cent less than the 16.86 tons on continuous cotton.

Thus we see that the reduced effectiveness of this rotation on the 11 per cent slope as compared to the 7 per cent slope, was largely in the oats and the cotton seasons. We may conclude then that, while this 3-yr rotation of oats—Kobe lespedeza, lespedeza, and cotton or corn is effective for runoff and erosion control on land with slope no greater than 7 per cent, there is not sufficient protection during the periods when oats and row crops are grown on land with 11 per cent slopes. Stronger vegetative control is needed for adequate protection on the steeper slopes.

The very low annual soil and water losses from the corn in the kudzu rotation reflects the powerful effects of heavy residues for controlling runoff and erosion, even on steep land. Kudzu occupies the land for nearly all of the 3 yr because it quickly recovers in the corn when cultivation is completed.

From the foregoing discussions we may draw at least seven conclusions:

1 Erosion on sloping row-crop land increases rapidly as the slope becomes steeper, even though the land is terraced.

2 Erosion on sloping land planted continuously to cotton (or other row crops) varies widely from one year to the next.

3 On the average, the greatest erosion hazard is in the row-crop growing season when the land is the most vulnerable.

4 The dead residues of summer cover crops used gave more protection to the land against fall and winter erosion than did the winter cover crops of oats and vetch.

5 The winter and summer legumes interplanted between continuous row crops did not give enough protection to the land on moderately steep slopes.

6 A 3-yr rotation of oats-lespedeza, lespedeza, and cotton or corn adequately reduced soil losses on land with 7 per cent slope. Erosion from the oats and rowcrop portions of this rotation, however, was too great on 11 per cent slopes.

7 Perennial cover crops like sericea lespedeza and kudzu gave excellent runoff and erosion control on steep slopes, even when turned under occasionally for row crops.

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Lightning Protection

(*Continued from page 172*)

under all secondary lightning surges. Out of approximately 100 installations three failures were reported. With the cessation of hostilities in 1945 this work was resumed where it was discontinued in 1941, but with the added knowledge of five years' experience. Accordingly, another unit was designed and about 50 installations were made during the 1946 lightning season. No failures were reported, and from comparative laboratory tests we know this device will withstand anything short of direct lightning. That, of course, it will not take.

In summarizing, I would emphasize that with an Underwriters' Laboratories "master label" installation of lightning protection on farm buildings and a proper capacitor to protect the electric wiring in those buildings, a farmer will have 100 per cent efficient protection from lightning. The fully protected building is one which never reveals its need for protection.

Farm Reservoir and Pond Program for Canadian Prairies

By H. D. Ayers
JUNIOR MEMBER A.S.A.E.

IN 1930 the Canadian prairies which had been hitherto relatively prosperous entered a period of combined drought and economic depression. The severity of these conditions was unprecedented in the history of settlement in the region. The Prairie Farm Rehabilitation Act (P.F.R.A.) was passed in 1935 by the Dominion government to provide assistance to farmers in combatting the severe effects of drought in the prairie provinces. Among other things, one of the main objectives of the Act was to increase supplies of water for agricultural purposes by the fullest possible development of surface water resources.

The area to which the Act applies covers the southern portion of the three prairie provinces, Manitoba, Saskatchewan, and Alberta. It is roughly triangular in shape, the base of which is the International Boundary, extending 750 miles from the Red River in the east to the Rocky Mountains in the west. The apex of the triangle is 320 miles north of the border on the Saskatchewan-Alberta boundary. This area comprises a total of 105 million acres of land, of which 78 million acres is occupied farm land, making up 172,000 farm units. Of this occupied farm land two-thirds are cultivated and one-third is used for pasture. Farming practices within the P.F.R.A. area range from diversified farming enterprises in western Manitoba and eastern Saskatchewan to straight grain farming in central Saskatchewan, and grain and ranching enterprises in western Saskatchewan and Alberta. Not only is this an area of high cereal grain production, but in 1936 it supported a livestock population of well over four million head. It is quite evident that the rehabilitation of this area was and still is of major importance to the agricultural economy of Canada.

Water is vital to the agricultural prosperity of any region. Because of the low annual rainfall in this district, considerable difficulty has been encountered in obtaining adequate water supplies for agricultural purposes. Ground water seldom occurs at shallow depths which may be economically tapped for farmstead use. Most of the ground water is high in soluble salts, even where it does occur at shallow depths. The chemical quality of the ground water supplies in the P.F.R.A. area make it generally unsuitable for domestic purposes and irrigation, and in some cases has even been unpalatable for livestock. Most of the streams rising in the prairies flow only during the periods of the spring runoff. Although fairly reliable

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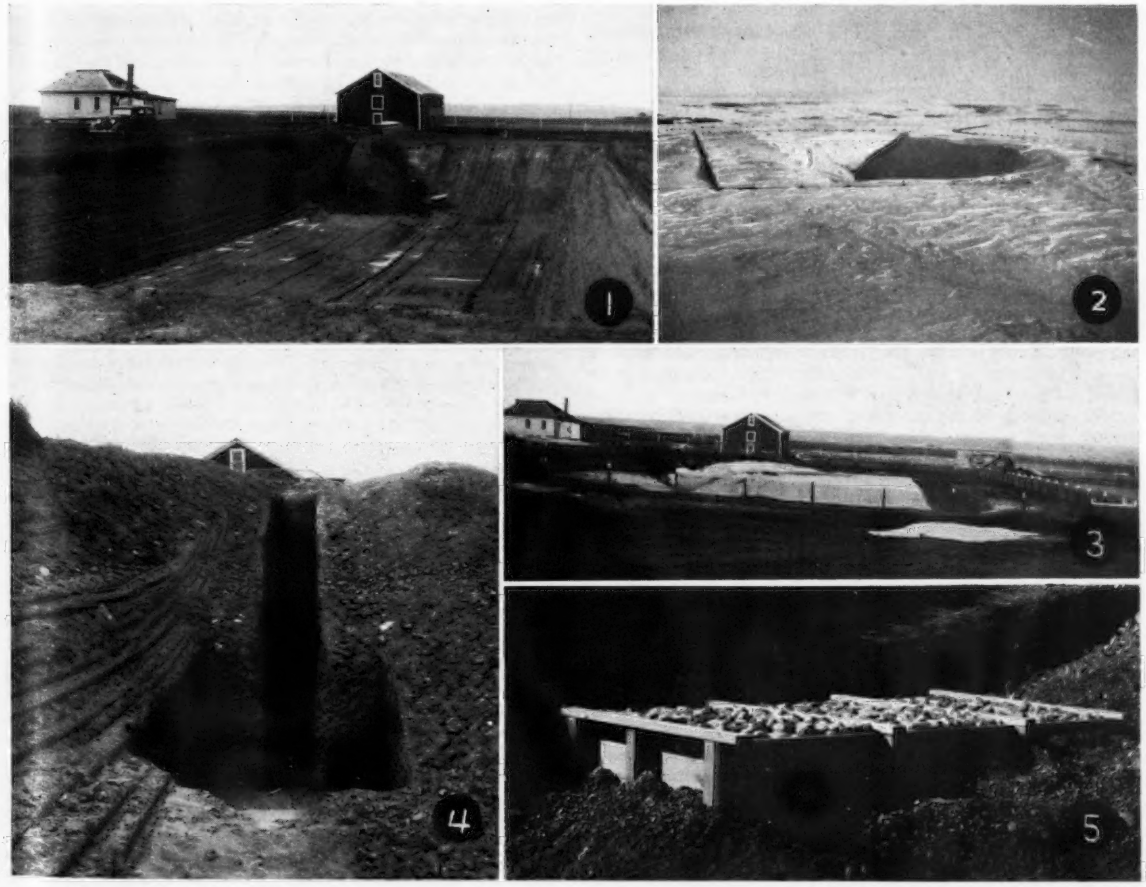

Fig. 1 Completed dugout with excavation for filter and well • Fig. 2 Winter scene of dugout. Much snow is deposited in dugout by wind action • Fig. 3 Dugout filled from spring runoff. Water is almost overflowing from low corner at far right • Fig. 4 Close-up of excavation for filter and well • Fig. 5 Complete filter installation. A plank covering is recommended with a screened inlet pipe on the near corner

water supplies are obtainable from rivers flowing from the Rockies, these become concentrated in a few widely separated streams which flow in deeply entrenched valleys over most of the prairie area, so are limited in their utility for agricultural purposes.

The water-development program of the P.F.R.A. provides assistance for the construction of large and small projects. The large projects consist of storage and irrigation works on larger streams and are intended to provide rehabilitation on a community scale. The small projects are intended to provide assistance to individual farmers in the utilization of surface water resources for irrigation, livestock, and domestic uses.

The guiding principle of rehabilitation by the conservation of surface water supplies on small projects has been the provision by the government of engineering services and financial assistance to bring the desired project within the financial means of individual farmers. It has been necessary to make adjustments in the rates of financial assistance during the 14 years of P.F.R.A. activity. Farmers in the more favorable crop districts were better able to avail themselves of assistance under the Act, than those in areas of severe drouth. It was these latter farmers whose rehabilitation was most urgent. Thus at times it has been necessary to provide additional financial assistance in localized areas to stimulate water conservation measures.

The small water development projects of the P.F.R.A. have been mainly in the form of dugouts (excavated ponds), stockwatering dams, and irrigation projects, many of which were diking systems utilizing spring runoff water only.

The scale of assistance provided at present under the Act for the construction of dugouts and dams for individual farmers is as follows:

1 *Dugouts.* Free engineering service is provided. Financial assistance is provided at the rate of 4½c per cu yd for earth work up to a maximum of $125.00.

2 *Stockwatering Dams.* Free engineering service is provided. Financial assistance is provided at the rate of 4½c per cu yd for earth work, and 25c per cu yd for rock work up to a maximum of $150 for earth, rock, and other materials. Where two or more farmers may find it advantageous to pool their water resources, assistance is provided on the same unit basis for earth, rock, and materials up to a maximum of $500.

WATER DEVELOPMENT PROGRAM CREATES INTEREST

The water development program of the P.F.R.A. has attracted considerable interest since its inception. Although less spectacular than large irrigation projects, the small water development projects have probably contributed much more to the rehabilitation of western Canadian agriculture and to the stabilization of the agricultural economy of Canada.

As evidence of the success of the program, approximately 37,000 small projects have been constructed in the P.F.R.A. area from 1935 up until the end of 1948. This averages a project on one in every five farms. The most popular type of development has been the dugout, of which there have been 31,000 constructed. This is 84 per cent of the total number of projects. There have been only 5,000 stockwatering dams constructed in the same period, or about 13 per cent of the total, while irrigation projects comprise 3 per cent. In other words, 97 per cent of the development has been devoted to the provision of water supplies for livestock and domestic purposes.

Since the use of dugouts has been so popular as a method of water storage, it merits special consideration. The vast experience in the construction of dugouts, and research into the utilization of dugout water supplies has resulted in many improvements and a broader utility of this type of structure.

A typical dugout conforms to the following dimensions: length, 160 ft; width, 60 ft, and depth, 12 ft. The side slopes are 1½ or 2 to 1. End slopes are usually 3 or 4 to 1. The earth work involved in such a dugout would be about 2500 cu yd. The dugout will have a capacity of 390,000 Imperial gallons, or 485,000 U.S. gallons. This is approximately 1.43 acre-feet of storage. Practically all of the dugouts now being constructed on the Canadian prairies conform to these dimensions. A dugout of this size has sufficient capacity to provide a summer water supply for 100 to 125 head of cattle, or a year-round supply for household and 40 head of stock.

Extremes of temperature in the prairie provinces make it necessary to provide for relatively deep ponds with small surface areas. The temperature range is from 100 F in the summer to −50 F in the winter. Temperatures are below freezing for the greater part of the period from November to March inclusive. A provision of 3 to 4 ft of dugout depth is made for evaporation and seepage losses. When a year-round supply of water is required, a minimum depth of 3 to 4 ft of water in the dugout prior to refill by spring runoff is essential to ensure a continuous supply of fresh water. Therefore, of the total dugout depth of 12 ft, an allowance of 8 ft of depth is made for water losses and reserve supply. Where the dugout water is to be used throughout the winter, it is necessary to have a depth of 5 or 6 ft of water in the dugout prior to freezeup so that a dependable supply of water is available below the ice layer.

Where dugout water is to be used for garden irrigation, a separate dugout is advisable because the entire supply will frequently be used during the summer months.

DUGOUT-TYPE OF POND IS POPULAR

The popularity of this type of pond is chiefly due to its ease of construction and the wide range of locations available within a given drainage area. Dugouts are usually constructed by wheeled or track-type tractors using tumblebugs or scrapers. Only occasionally are draglines used. In most cases equipment is rented or the work is contracted locally by small custom operators. The many available locations usually permit the construction of dugouts close to the point of maximum use, such as within the farm building area, close to gardens or at convenient points in pasture areas. The drainage area required on relatively flat plains areas with no trees is 100 to 150 acres. On gently rolling land of definite drainage slopes, a drainage area of 50 to 80 acres is sufficient. A dugout that is properly located within a farm building area may be easily filled with the runoff water from the snow trapped in a shelterbelt surrounding a 2-acre garden area. The major limitation regarding dugout location is the nature of the subsoil. Exploratory work is always necessary to assure that the dugout will be constructed in a relatively impervious material so as to minimize seepage losses.

The total cost of a dugout averages from $250 to $300. Thus the government provides one-third to one-half of the total cost, and the farmer the rest, under the P.F.R.A.

The use of dugouts for domestic water supplies has become increasingly popular. This is particularly true where suitable supplies of ground water cannot be obtained at depths of less than 200 ft. The utilization of dugout water for domestic purposes has presented certain problems not previously confronted in reservoir and pond construction. It is not only necessary to control the chemical quality of the water but the bacterial quality, color, and odor require careful attention. It is obvious that farmers cannot utilize water treatment facilities similar to those available to urban dwellers.

The experience of farmers and the research work of government agencies has made it possible to solve many of these problems. The results of this experience and research may be summarized in the form of recommendations to those who contemplate developing dugout water supplies for domestic purposes. The recommendations are as follows:

1 *Dugout Protection.* The dugout must be tightly fenced to keep out all domestic animals and fowl. The dugout must be protected and situated so that all possible pollution is prevented from contaminating the dugout water.

2 *Water Treatment.* The use of a sand and gravel filter in the bottom of the dugout has provided a satisfactory means of filtration. A common type of filter consists of a trench filled to a 3-ft depth with clean, well-graded sand, extending from the toe of the inside slope of the dugout to a well located at least 10 ft from the top edge of the dugout. The inlet end of the filter is covered with stones to protect the filter. The remainder of the trench is then backfilled with earth. However, the recommended type of filter consists *(Continued on page 183)*

Evaluation of Factors Affecting the Operating Stability of Wheel Tractors

By Wayne H. Worthington
MEMBER A.S.A.E.

(Continued from the March issue)

STABILITY CHARACTERISTICS OF TRACTORS WITH DRIVEWHEELS IMMOBILIZED

A COMPREHENSIVE analysis has been made of tractor backward upsets, based upon the best and most complete information available. It was found that comparatively few such accidents have occurred simply when pulling a load up a hill. Contrary to popular belief, upsets largely occur when the tractor is either pulling an unloaded implement or when the implement has been uncoupled from the tractor, and the drivewheels have in some manner become lodged or dug in, and the tractor is immobilized. As nearly as such events can be reconstructed, circumstances characteristically follow one of two pathetic and tragic patterns, as follows:

1 The tractor encounters soft ground—whether on the level or otherwise is of little consequence—the drivewheels dig in and become lodged or stuck, allowing the rear end to drop down. The driver next disengages the clutch. Frequently, in an effort to get out, the drawn load may be disengaged, although sometimes not. On occasion the drivewheels may be blocked or chained. The operator then shifts the tractor to low gear, "guns" the engine, and jams in the clutch. Within a split second, under the driving force of full engine power plus stored flywheel energy, the tractor rises in front, overbalances, and falls backward.

2 The driver attempts to cross a ditch and runs into a concealed low spot or strikes some obstruction, allowing the drivewheels to drop, dig in, or otherwise become prevented from turning. Events then follow the pattern just described.

Characteristic of this condition is that the tractor "frame" or "chassis" pivots or rotates about the rear axle whenever the engine applies sufficient torque through the final drive with the drivewheels solidly lodged. A study of Nebraska Official Test results reveals that some tractors are so powered and geared that full engine power in low speed will alone develop drive wheel torque sufficient to raise the front wheels from the ground when the tractor is level and the drivewheels immobilized.

The subject will be approached from the standpoint of torque, work, and inertia. Before undertaking a quantitative analysis, it is worth while to examine what is involved when a tractor is in this condition and the clutch is suddenly engaged. To overturn the tractor (Fig. 9), the center of gravity of the frame must be lifted to a point vertically over the axle. Work must therefore be done to (1) accelerate the frame at the start of the lift (although should angular movement slow down, this kinetic energy may in some degree be converted to potential energy as the center of gravity of the frame nears its greatest height); (2) lift the frame to the point of instability.

Assume that the engine is running at maximum governed idle speed and that the clutch be engaged sufficiently to transmit full engine power, which slows the engine down to governed load speed. So long as this governed load speed is maintained, energy from the flywheel, or attached rotating masses, is not available for lifting the frame. Any further reduction in speed, however, does make this energy available for lifting. Energy delivery to the final drive continues, at least down to the speed of maximum torque, and probably somewhat lower. The *entire* flywheel effort, however, is not available because, when the engine reaches some rather low speed, any remaining energy becomes dissipated as friction, including engine pumping losses.

Following is an evaluation of these factors as they apply to a representative, well-balanced, general-purpose tractor. Consider first that the tractor is level and the drivewheels are prevented from turning. (Later the same analysis is applied to a tractor with front wheels elevated.)

TABLE 1. TIPPING CHARACTERISTICS

Ratio:	Engine torque at rated speed	1320 lb-in
	Speed at maximum torque/rated speed	0.76
	Maximum engine torque	1460 lb-in

Gear	1st	2nd	3rd	4th	5th
Rear axle torque (rated speed), lb-ft		7880	5890	4440	2030
Rear axle torque (maximum), lb-ft		8550	6350	4780	2190
Frame rpm at maximum torque speed			16.68	21.5	48.4
Angular velocity of center of gravity, radians per second			1.75	2.25	5.07
Work to accelerate to this velocity, ft-lb			940	1560	7900

Work to accelerate = kinetic energy of mass at angular velocity, ω

$$= \frac{2\,W_f\,(j\omega)}{2 \times 32.2}$$

Work to lift through any angle, $\theta = W_f\,(j \sin\theta - i)$

Values of symbols shown in Fig. 9 for the subject tractor are as follows:

Total stability weight	= 4410 lb.
Weight of drivewheels, axles and final-drive gears	= 1270 lb
W_f (frame weight)	= 3140 lb
j (radial distance, center of rear axle to center of gravity of frame)	= 2.51 ft
i (vertical distance, center of gravity of frame above rear axle center)	= 0.491 ft
$\theta = \tan^{-1}(i/j)$	= 11.3 deg
M_{FS} = frame stability moment, lb-ft $= W_f j \cos\theta = 3140 \times (2.51 \times 0.9806)$	= 7730 lb-ft

Inspection of Table 1 reveals that the maximum rear axle torque in second speed (utilizing maximum engine torque) is greater than the frame stability moment. Therefore, should the drivewheels become completely immobilized, the power of the engine is sufficient to result in instability and overturning.

Were the tractor to be overturned in some higher speed, power supplied from the engine must be augmented by energy

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1948, as a contribution of the Power and Machinery Division. (This is the second and last part of this paper.)

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ACKNOWLEDGMENT: The author gratefully acknowledges his indebtedness to the following individuals, without whose cooperation, guidance, and help this work would not have been possible: Elmer McCormick (deceased), A. W. Clyde, W. F. Buchele, B. G. Rich, F. C. Walters, and T. Nakae.

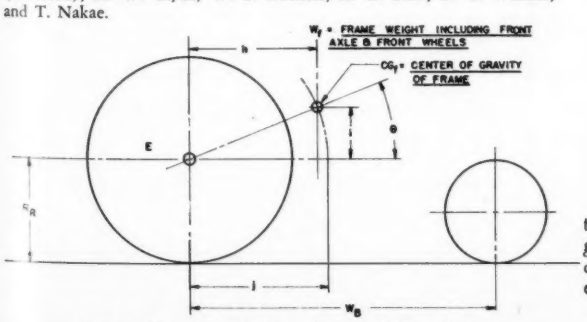


Fig. 9 This diagram shows frame stability values

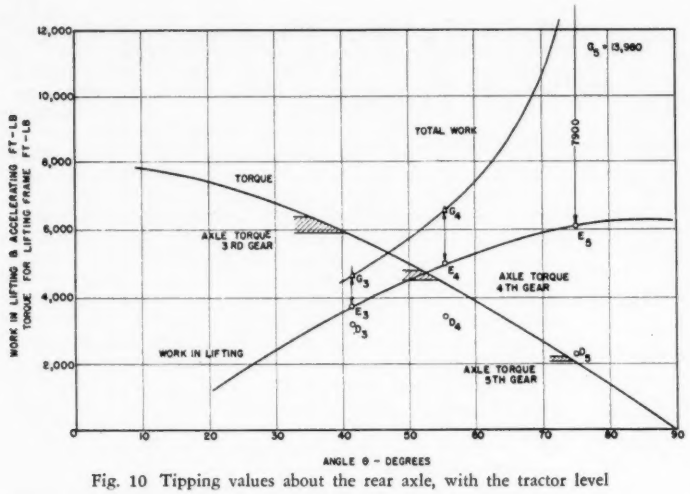


Fig. 10 Tipping values about the rear axle, with the tractor level

from the flywheel (1) to accelerate the frame and (2) to raise the center of gravity up to a point where the stability moment of the frame is reduced to a value equal to the rear axle torque supplied by engine power alone.

From Fig. 10, values of W_1 (work required to lift frame weight) are first plotted starting with θ equal to 11.3 deg (tractor level) and continuing to 90 deg (with center of gravity vertically over axle). Next are plotted values of torque at the rear axle exerted in lifting the frame through the same range of angles.

Rear axle lifting torque = frame stability moment
$= W_f\ (j \cos \theta)$

Torque applied to the rear axle by the engine (without loss of speed) is then indicated for third, fourth and fifth speeds with torque values shown throughout the engine speed range between that of maximum torque and rated governed. From this it is shown how far CG_f must be rotated until the axle torque derived from the engine alone (without flywheel inertia augment) is sufficient to carry it "over the top" to complete instability. For example, in fourth gear, when angle θ attains 55.3 deg, the normal rear axle torque (from the engine) of 4,400 lb-ft will continue the motion. The work accomplished with a torque of 4,400 lb-ft acting through an angle of 44 deg (55.3 deg − 11.3 deg) is next calculated as follows:

Work = (44/360) x 4440 x 2π
= 3410 ft-lb (This value is that shown at D_4)

Table 1 gives 1.560 ft-lb as the work needed to accelerate the frame in fourth gear, with the engine speed dropping off from governed load speed to that of maximum torque. This must be added to the 4,940 ft-lb of work of lifting, to where θ = 55.3 deg, so that the total work requirement equals 6,500 ft-lb. This is shown on Fig. 10 as G_4. Tabulating

Total work requirement	6,500 ft-lb
Work supplied by engine	3,410 ft-lb
Energy taken from flywheel (resulting in speed drop)	3,090 ft-lb

TABLE 2. TYPICAL TRACTOR LIFTING FROM LEVEL POSITION AT RATED ENGINE SPEED
θ = 11.3 deg

Gear	3rd	4th	5th
Degrees of motion before maximum axle torque will continue motion	30	44	64
Work to accelerate frame, ft-lb	940	1560	7900
Work in lifting frame, ft-lb	3650	4940	6080
Total work to lift and accelerate frame, ft-lb	4590	6500	13980
Engine work at rated speed during above angular motion, ft-lb	3150	3410	2250
Energy drawn from flywheel to complete lift, ft-lb	1440	3090	11730
Drop in engine speed to release this work, per cent	8	18	——

From Fig. 11 it is seen that this amount of energy is available as work when the flywheel speed drops 17.5 per cent. It is therefore concluded that under full governor action the tractor will overturn.

Table 2 gives similar data for fourth and fifth speeds as well. Such data for first and second speeds are omitted, however, because it is obvious that axle torque supplied from the engine alone, without flywheel energy augment, is sufficient to lift the frame if the drivewheels are so immobilized that they cannot turn.

This same method of analysis may be applied to conditions existing where drivewheels are down in a ditch, or "dug in", affording an initial elevation to the front end, which may be designated as angle α. This is added to 11.30 deg to give the initial value of angle θ_1. Consider the tractor previously analyzed, which has a wheelbase of approximately 90 in with the front wheels elevated 15 in. The angle of incline of the frame with the ground is then 9.7 deg and the new angle is

$\theta_1 = 11.3 + 9.7$
$= 20$ deg

Revised tipping values have been calculated and tabulated in Table 3.

TABLE 3. TYPICAL TRACTOR LIFTING WITH WHEELS IN 15-IN DITCH
θ_1 = 20 deg

Gear	3rd	4th	5th
Degrees of motion before maximum rear axle torque will continue motion	20.3	34.7	54.4
Work to accelerate frame, ft-lb	940	1560	7900
Work in lifting frame, ft-lb	2444	3734	4874
Total work to lift and accelerate frame, ft-lb	3384	5294	12774
Engine work at rated speed during above angular motion, ft-lb	2130	2690	1910
Energy drawn from flywheel to complete lift, ft-lb	1254	2604	
Drop in engine speed to release this work, per cent	7	15	

In Fig. 12, a new work curve is shown, starting at the new

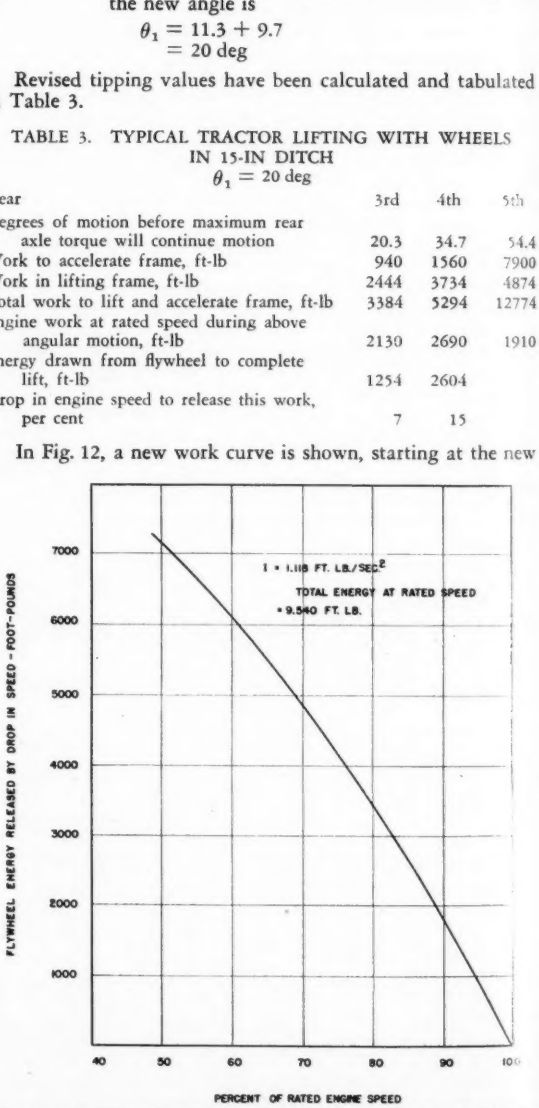


Fig. 11 This curve shows the energy of the flywheel and attached parts

value of θ_1 (20 deg), and points G_3, G_4, and G_5 are correspondingly lowered. The rear axle torque curve remains unchanged. The values of points E_3, E_4, and E_5 are all decreased because fewer degrees of frame rotation are required to reach the point where motion continues as the result of normal rear axle torque alone. As will be expected, it shows that the drop in flywheel speed necessary to affect overturning is reduced.

The time required to lift the front end to a point of complete instability is dangerously small, whether or not the tractor is level or with the front wheels elevated. A comparison of these values is shown in Table 4.

The preparation of Table 4 was based upon facts developed by previous analysis as follows:

1 In both first and second speeds, the rear axle torque from the engine alone (without flywheel energy augment) is sufficient to overturn the tractor with drivewheels immobilized, either when the tractor stands level or the front wheels are elevated.

2 Time factors calculated for third and fourth speeds assume that the engine speed has dropped to afford the necessary flywheel energy augment. In neither case has the engine speed dropped to that of maximum (peak) torque.

TABLE 4. TIPPING TIME TO COMPLETE INSTABILITY

Travel Speed	1st	2nd	3rd	4th
Time to complete instability, sec				
Tractor level	1.340	0.823	0.614	0.566
Front end high	1.197	0.722	0.577	0.484

The time elements involved are short as compared with human reaction time, which makes this type of operation particularly hazardous. The particular tractor considered in this analysis has advertised low and second speeds of 1½ and 2½ mph, respectively. The factor of safety, considered as the difference between human reaction time and the tipping time to complete instability in first speed, as compared with that in second speed, evidences the great safety value afforded by the "low-low" or "creeper" speed. The evaluation of this safety factor is rather unpredictable, because human reaction time, particularly that of a thoroughly scared and "rattled" human, has not been determined definitely. It is our own thinking that the critical factor resulting from miring down of the drivewheels is not the reduction in the work values necessary to effect upsetting, *but that the drivewheels are sufficiently immobilized to resist the rear axle torque necessary for upsetting the tractor.*

The above analysis is based upon the assumption that the drivewheels are completely immobilized, such as would occur when frozen to the ground, or, as has been frequently reported, chained to a post jammed down in front of the drivewheel. Even though traction conditions may not afford complete immobilization, the resistance of heavily weighted drivewheels to rapid angular acceleration can attain high values when the clutch is suddenly engaged.

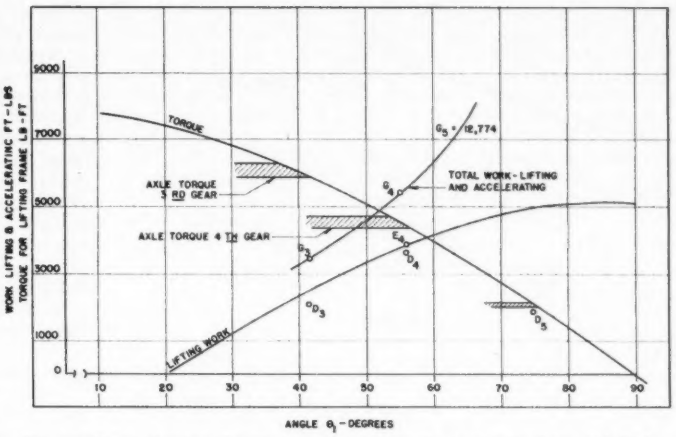


Fig. 12 Curve showing the tipping values about the rear axle, front end high

It will now be shown that in crossing a deep ditch the drivewheels may be supported solely at points ahead and back of the rear axle rather than from below. Analysis of one such accident follows, with conditions as shown in Fig. 13.

So restrained and with drivewheels immobilized, the front end tends to rise as the clutch is engaged. Three dynamic changes occur:

1 Weight is transferred to the drivewheels, up to the total tractor weight.

2 Torque applied to the rear axle, from the engine, is resisted by two forces: (1) traction afforded by contact of tires with ground; (2) angular inertia of weighted drivewheel.

3 The stability moment of the tractor frame decreases as the front wheels rise.

It has been shown previously that the engine power (together with flywheel inertia augment) results in sufficient rear axle torque to lift the front end from the ground. It has also been determined experimentally that, when standing unloaded on a cement floor, the angular inertia of the tractor's drivewheels, plus the static directional inertia of the entire tractor mass, were together sufficient to overcome the angular inertia of the tractor frame. For the purpose of this analysis, the entire tractor weight may therefore be taken as supported on the rear wheels alone. The tractor used for analysis is that previously considered.

W_t = total tractor weight
= 4410 lb

W_f = frame weight
= 3140 lb

$F_1 = F_2$
= toggling forces against ground resulting from tractor weight reaction

$$= \frac{W_t}{2 \cos (\text{contact angle}/2)}$$

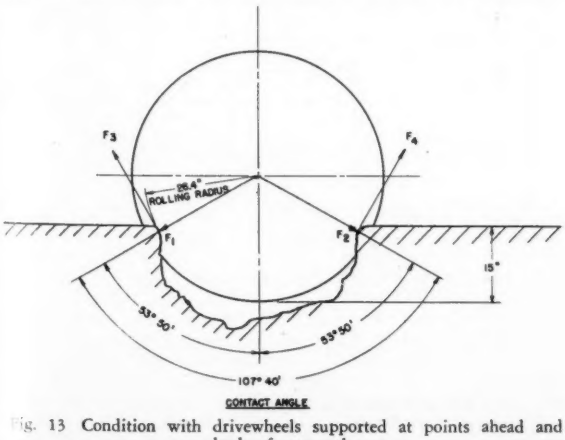


Fig. 13 Condition with drivewheels supported at points ahead and back of rear axle

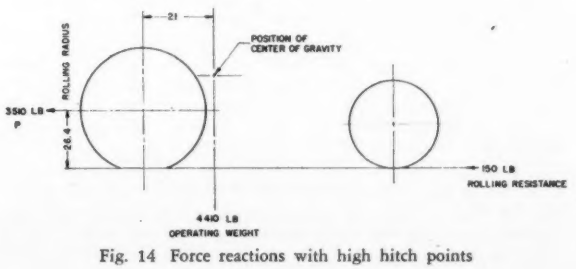


Fig. 14 Force reactions with high hitch points

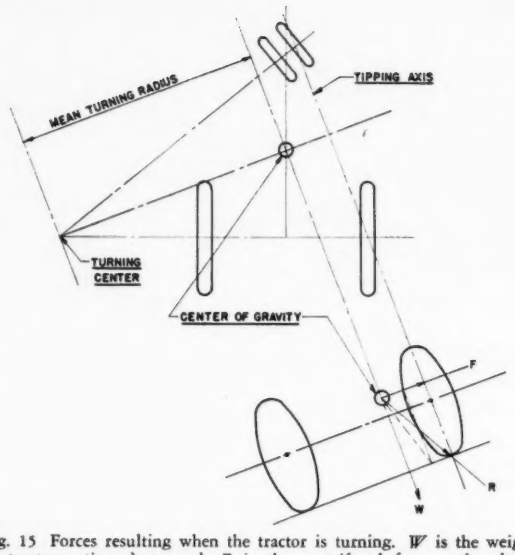


Fig. 15 Forces resulting when the tractor is turning. W is the weight of tractor acting downward, F is the centrifugal force acting horizontally, and R is the resultant

$$= 4410/(2 \cos 53° 50')$$
$$= 4410/(2 \times 0.5901) = 3735 \text{ lb}$$

Where μ = traction coefficient and 26.4 in = tire rolling radius

$$\text{Rear axle torque} = 26.4\ \mu\ (F_1 + F_2)$$
$$= 26.4\ \mu\ (2 \times 3735)$$
$$= 197{,}200\ \mu$$

With the front wheels elevated 15 in as shown, angle θ to frame center of gravity becomes 20 deg and the length component of the frame stability moment ($j \cos 20$ deg, Fig 9) has a value of 28.3 in.

The frame stability moment therefore becomes

$$M_{sf} = 3140 \text{ lb} \times 28.3 \text{ in}$$
$$= 89{,}000 \text{ lb-in}$$

Equating values of frame stability moment and rear axle torque, and solving for the traction coefficient, μ,

$$197{,}000\ \mu = 89{,}000$$
$$\mu = 0.452$$

Many published reports of tire traction tests reveal traction coefficient values, on firm soil, *well in excess* of 0.452.

The above analysis evaluates the traction conditions necessary to immobilize a drivewheel, showing that they are in everyday field existence. Accidents have also occurred as the result of drivewheels breaking through a hard, top crust into a soft, lower soil, affording little support. Under such conditions, the tire is supported at points comparable with those shown in Fig. 13 and the same type of analysis may be applied, with comparable results.

In his analysis of traction conditions, McKibben called attention to the decrease in stability moment resulting when the tips of drivewheel lugs become caught over a high forward obstruction. (AGRICULTURAL ENGINEERING, vol. 8, no. 5, page 121). It must be borne in mind that comparable lack of stability may result with cleated rubber tires when

(a) A high, sharp obstruction is encountered which will engage the tire lugs sufficiently to hold against slippage.

(b) Tractor drivewheels become mired down and the operator forces a stone or post in front of the tire to engage a tire lug. A fence post or other heavy chunk of wood chained to the wheel to facilitate getting out of a hole or other low spot in a field, results in the same condition. McKibben shows this loss of stability as a variable, but it may be similarly evaluated for present-day conditions.

A still further cause of danger results from hitching the drawn load too high. Several upsets have been reported resulting from pulling a heavy load with a chain hitched around a rear axle housing. The resulting condition is that shown in Fig. 14, which is again analyzed on the basis of the subject tractor. It will be seen here that a horizontally applied pull of but 3510 lb will effect instability, which with the entire weight transferred to the drivewheels occurs at a traction coefficient (μ) value of 0.797. When one considers that during the official Nebraska Tractor Test, the subject tractor developed a drawbar pull in excess of 3600 lb, the possible results of such careless operation are appalling.

It was recently our privilege to observe a tractor engaged in hauling logs into a veneer mill. An outrigger had been built out some two feet behind the rear axle center, with a hitch point approximately three inches above the rear axle center. Logs were hitched to the outrigger with a chain at an angle of about 35 deg with the horizontal. Under these conditions, the subject tractor would become unstable at a horizontally applied drawbar component of 2150 lb, approximately equivalent to its Nebraska Tractor Test performance in fourth speed.

There is probably no greater potential source of danger to the operator than that arising from the use of such makeshift equipment built and operated in entire ignorance of tractor dynamics.

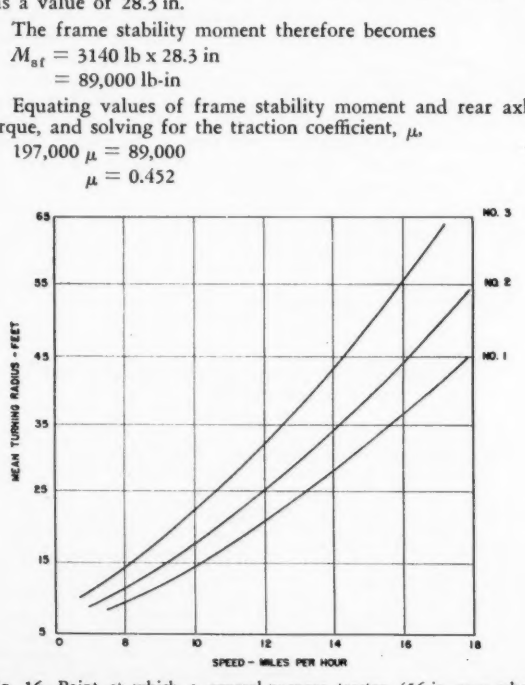


Fig. 16 Point at which a general-purpose tractor (56-in rear wheel tread) becomes unstable in turning, due to centrifugal force. Curve 1, on level ground; curve 2, on 5-deg slope; curve 3, on 10-deg slope

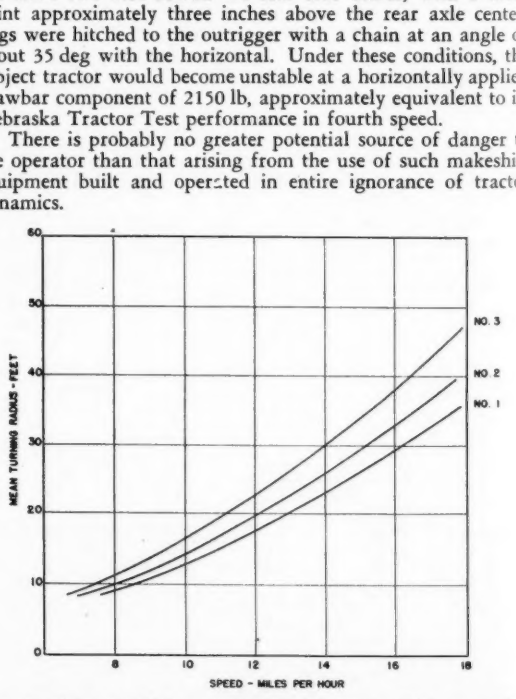


Fig. 17 Point at which a general-purpose tractor (84-in rear wheel tread) becomes unstable in turning, due to centrifugal force. Curve 1, on level ground; curve 2, on 5-deg slope; curve 3, on 10-deg slope

Sideways upsets have been carefully investigated and found to result almost entirely from "cutting corners" at high speed, racing, operating with gears in neutral, or running off a road or over an embankment. Our analysis would be incomplete, however, were no evaluation of this condition undertaken. For this reason, Figs. 15, 16, and 17 are included, although similar data were presented some time ago by the late Elmer McCormick, former chief engineer of the John Deere Waterloo Tractor Works.

An analysis has been made of the subject tractor to determine the travel speeds at which it becomes unstable laterally on a turn. The analysis is made assuming no wheel weights, and without water in the tires, a condition usually taken as indicative of high operating stability. Fig. 15 shows this tricycle tractor supported on its four wheels by forces acting normal to the surface of the ground through the points of tire contact. Obviously, the tractor remains stable only so long as the resultant of all forces, including its own weight, falls inside the lines connecting the points of support. When undertaking a turn, other forces are created, and the centripetal forces acting through the tire contacts on the ground are equal and opposite to the centrifugal force acting through the center of gravity.

On this particular tractor, centrifugal force acts through the center of gravity at a height of 31.4 in above the ground (with a drivewheel rolling radius of 26.4 in) and is resisted only by the opposing centripetal forces acting at the surface of the ground, through the points of tire contact, and a lateral unbalancing or overturning couple results. The tractor remains stable and upright only when the resultant, *R*, of the weight and centrifugal forces, falls inside the line connecting the points of ground contact of the outer front and rear wheels. Evaluating the fundamental formulas, the relationships between travel speed and the turning radius (taken from the contact point of the inside tire), at which the tractor becomes unstable, are shown in Figs. 16 and 17 for 56 and 84-in rear wheel tread adjustments, respectively. For the sake of simplicity, the tractor has been considered strictly as a free body, and with a maintained center of gravity revolving about a center of rotation. It must be recognized that there are other forces and reactions, such as changes in the fluid levels within the fuel tanks and transmission housing and variations in the deflections of the inner and outer tires due to the shifting reactions of weight and centrifugal forces, which in their combination tend to augment rather than reduce the factors resulting in instability.

Undoubtedly an increased tempo in farming operations is at hand, but any substantial over-all increase will probably result not so much from increased speed alone as from implements which will more effectively utilize speeds now available.

Presented in this paper are the results of studies undertaken to assemble and develop a method for evaluating the many factors affecting the operational stability of wheel tractors. The design of today's tractors is evidence of the great strides made toward building into them many elements making for inherently safe and stable operation. Study and evaluation of the fundamentals involved leads to a better understanding of their nature, and more especially to what educational steps might bring about greater "safety consciousness" and promote more intelligent operation.

Farm Reservoir and Pond Program

(*Continued from page 178*)

of a 3-ft depth of clean, well-graded sand, contained in a wooden box 10 ft long, 5 ft wide, and 5 ft deep. The sand is underlain by a 1-ft layer of clean, uniform ⅛ to ¼-in size gravel. The top of the sand is protected by gravel and stones of 2 to 4-in diameter. The box is located at the toe of the inside slope, with the bottom 2 ft below the dugout bottom. It is completely enclosed except for an inlet pipe and a discharge pipe. The inlet should be located at the top edge on the dugout side and should be provided with a coarse screen. The discharge pipe should be finely screened at its inlet, and should be laid from the bottom of the filter to a well at least 10 ft from the edge of the dugout. Standard 2-in water pipe is satisfactory for this purpose. The large surface area of this filter will be more than adequate to meet the demands for domestic purposes. In fact, the filtering capacity per square foot may be reduced to one-quarter of the optimum filtration rate and still provide 600 gal of water per day. This will permit the filter to operate over a period of years without maintenance. The advantages of this latter type of filter are that it has a more accessible location when servicing is required, and water is taken from above the bottom and away from the sides of the dugout. This latter advantage is important in that there is better control of the chemical quality of the water.

3 *Well.* The well must be constructed to conform to the sanitary requirements of public health regulations.

4 *Control of Vegetation.* The decay of organic matter in dugouts results in the production of CO_2. This in turn may produce a high concentration of carbonate salts in the water, or it may impart a quality of hardness to the water. The anaerobic decomposition of organic matter may also result in the reduction of the insoluble ferric compounds to the soluble ferrous compounds. Water having an iron content of over 0.5 ppm is unsuitable for laundering purposes. It is therefore necessary to prevent all vegetative growth within dugouts. Growth around the edge of the dugout should be limited to short-grass. Deciduous trees should be planted no closer than 100 ft from the dugout.

5 *Control of Algae.* The use of copper sulphate at rates of 2 to 3 lb per million gallons has proven satisfactory in the prevention of objectionable odors by the control of microscopic organisms.

6 *Watershed Protection.* Since the dugout is filled only during the period of spring runoff, it is fairly easy to maintain a pasture or grassed area comparatively free from pollution by domestic animals for a short period prior to the spring thaw.

With adherence to the foregoing recommendations, there is little doubt but what the water supply will be as dependable and safe as that from a well tapping the ground water supply. In addition, the water will be much more suitable for general household use than most ground water supplies in the area.

SILT DEPOSITION IN DUGOUTS A PROBLEM

One other problem in addition to those previously discussed is that of silt deposition in dugouts. This has not been a problem on grassed watersheds. It is, however, reducing the effective storage of dugouts in grain-growing areas. This may be overcome by providing desilting areas or grassed channels in the dugout approaches. As yet little has been done to overcome silting of dugout ponds by this method.

While the major interest in small water development projects has been directed towards the construction of dugouts, the ranching areas of southwest Saskatchewan and southern Alberta have a topography more favorable for the construction of small dams. It is in this area that the majority of the stockwatering dams constructed under the P.F.R.A. have been built. Almost all of the dams have been of the earth fill type, constructed with scrapers and wheeled tractors owned by local farmers.

A typical stockwatering dam would be 10 to 25 ft high, with a top width of 10 ft and 3 to 1 side slopes on the wet side, and 2 to 1 slopes on the dry side. Most of the dams are constructed with 3 to 4 ft of freeboard. All dams are protected on the upstream face with rock riprapping. As a rule no core walls are used in the small dams. The only protection taken against seepage is stripping of the top 6 to 18 in of foundation material on the dam site, and judicious selection of a relatively impervious reservoir site. In some cases it is necessary to plow a core trench after stripping. Sites are usually selected which may take advantage of a natural depression below the crest elevation of the proposed dam for a natural grassed spillway.

The small water developments program of the Prairie Farm Rehabilitation Act was designed to provide assistance on a self-help basis to individual farmers and ranchers in developing surface water resources for their individual use. The program has met with considerable success in the rehabilitation of prairie agriculture.

Hydraulic Characteristics of Vegetation for Vegetated Waterways

By W. O. Ree

A HYDRAULICIAN recently said that guessing the velocity in a channel containing vegetation is an art rather than a science. Apparently engineers are now invading the province of art. They are making a science of estimating the velocity in such channels. Experiments have been run by the Soil Conservation Service to determine the hydraulic characteristics of vegetation in channels. These experiments are performed at outdoor laboratories under field conditions. The data thus obtained are directly applicable to the design of similar channels in the field. Before proceeding with a presentation of these data a brief description will be given of the Stillwater Outdoor Hydraulic Laboratory where most of this work is being done.

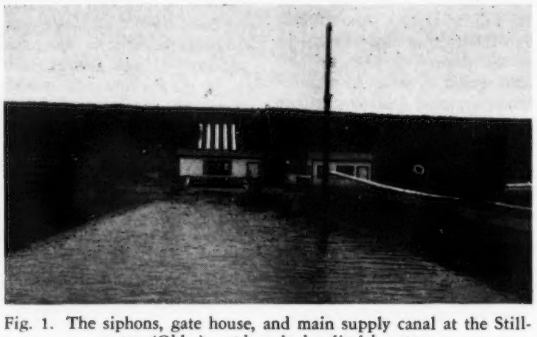


Fig. 1. The siphons, gate house, and main supply canal at the Stillwater (Okla.) outdoor hydraulic laboratory

The laboratory is a project of Soil Conservation Service (Research) and is located at Stillwater, Okla. Its main features are an area of sloping land where waterway experiments can be constructed, a supply of water to be used in testing, gates and canals to control and convey the test flows, and the necessary measuring equipment. There is ample space and water supply. The laboratory site covers about 75 acres and the lake holds about 50,000 acre-feet of water. The test channels vary in width from 3 ft to 40 ft and in length from 100 ft to 500 ft. Test flows range from 0.01 cfs to 175 cfs. Slopes up to 10 per cent are possible on the site. The water for testing is taken from the adjoining lake through a siphon of five 20-in pipes. The maximum flow capacity of this structure is about 175 cfs. Fig. 1 is a view of the siphon and a part of the supply canal which conveys the water to the experiments.

The hydraulic characteristics being studied at the laboratory include the resistance offered to flow by the vegetation, the protection offered the channel bed, and the effect of vegetation on the flow characteristics in the channel. Each of these will be discussed in turn. Suggestions also will be offered on the use of these data in the solution of design problems.

Resistance to Flow. The most important hydraulic characteristic of a vegetation is the resistance it offers to flowing water. A common measure of this resistance is the retardance coefficient in the Manning formula. This formula is usually written as $[V=(1.486/n)\ R^{2/3}\ S^{1/2}]$ where V is mean velocity, R is the hydraulic radius, S is the slope, and n is the retardance coefficient. This coefficient will be referred to as Manning's n. In passing it might be well to mention that Kutter's n and Manning's n are not the same. They are equal when R equals one meter but differ for all other values of R. This difference is large for small rough channels. In this paper only the Manning n will be used.

Determinations of Manning's n have been made for different vegetations under a variety of conditions. In each instance the procedure was the same. The vegetation to be evaluated was established in a channel. When it was desired to test the vegetation, a series of measured flows of water were passed down the channel. During each flow measurements were made which enabled the determination of the hydraulic elements. By substitution in the Manning formula the value of n was computed for each test. Experiments were performed on a number of vegetations in channels of various slopes and cross sections. Tests were also made at different times of the year and under different maintenance practices.

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1948, as a contribution of the Soil and Water Division.

W. O. REE is project supervisor (research project OK-R-3), Soil Conservation Service, U. S. Department of Agriculture. (Stillwater, Okla.)

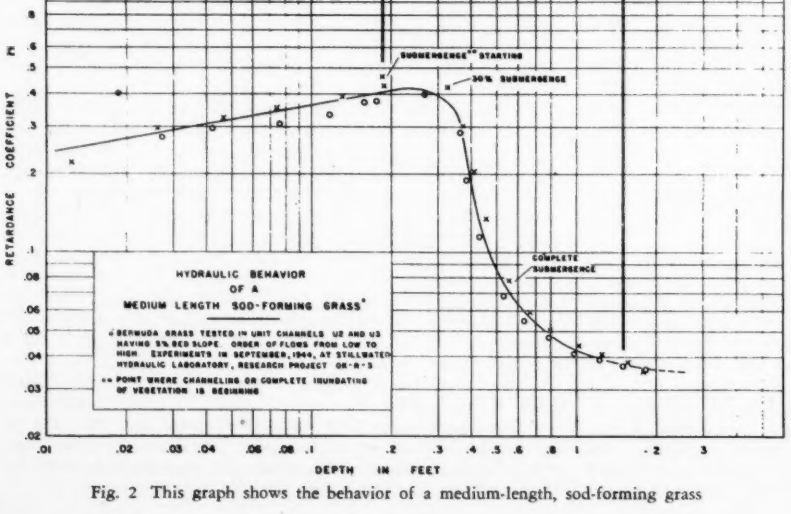

LOW FLOWS
INTERMEDIATE FLOWS
HIGH FLOWS
RETARDANCE COEFFICIENT n
DEPTH IN FEET
SUBMERGENCE** STARTING
50% SUBMERGENCE
COMPLETE SUBMERGENCE
HYDRAULIC BEHAVIOR OF A MEDIUM LENGTH SOD-FORMING GRASS*
* BERMUDA GRASS TESTED IN UNIT CHANNELS 12' AND 16' WIDE HAVING 5% RED SLOPE. ORDER OF FLOWS FROM LOW TO HIGH. EXPERIMENTS IN SEPTEMBER, 1946, AT STILLWATER HYDRAULIC LABORATORY, RESEARCH PROJECT OK-R-3
** POINT WHERE CHANNELING OR COMPLETE INUNDATING OF VEGETATION IS BEGINNING

Fig. 2 This graph shows the behavior of a medium-length, sod-forming grass

The most striking thing observed about the values of Manning's n obtained was their great range. Values ranged from 0.02 to 0.6. Even one vegetation in a single channel would show nearly this variation. An example of this is shown in Fig. 2. This diagram shows the results of tests on two identical Bermuda grass channels. The values of Manning's n are plotted against corresponding values of depth. The range of n here is seen to be from over 0.4 to less than 0.04. An explanation for this variation is found readily if the behavior of the grass during this experiment is considered. The flows of very small depth encountered a maximum resistance as indicated by the large n values. In this range the vegetation is upright in the flow and is neither bent nor submerged. The gradual increase in this range may be due to the greater bulk of vegetation encountered at the slightly greater depths. As the dis-

charge is further increased, a depth is reached where some of the grass is bent over and submerged. The n values then start to decrease rapidly with increase in flow depth. When bending and submerging are complete, the n curve starts to level out approaching a constant value. All vegetations tested at the laboratory behaved in this same manner and resulted in the same type of curve.

The retardance coefficient picture was further complicated by the discovery that similar vegetations have different n-depth curves for channels of different slope or cross section. Each combination of vegetation, channel cross section, and channel slope would yield a different n-depth curve when tested. Each channel seemed to be a law unto itself. The possibility of simple solutions for vegetal channel design problems seemed remote if not impossible. However, it was found that, if the n values were plotted against the product VR (where V is the mean velocity and R the hydraulic radius) instead of depth, approximately the same curve would be obtained for a given vegetation regardless of the type or slope of channel. It was further discovered that vegetations of similar physical characteristics would have similar n-VR curves. This finally led to a classification of vegetations on the basis of their n-VR curves. Five classes of vegetal retardance have been selected and given letter designations. These are given in Table 1.

TABLE 1. CLASSES OF VEGETAL RETARDANCE

Very high retardance	Class A
High retardance	Class B
Moderate retardance	Class C
Low retardance	Class D
Very low retardance	Class E

The average n-VR curve was determined for each class. Fig. 3 shows these five n-VR curves. The physical characteristics of the vegetation in each of these classes are given in Table 2.

An estimate of the flow-retarding properties of any vegetation can be made by comparing its physical characteristics with those described in Table 2 and selecting the corresponding degree of retardance. The average n-VR curve given for this retardance group will then provide the desired estimate. The retardance classes of the vegetations tested are given in Table 3.

One advantage of this system of classification is the elimination of the need for knowing the many values of Manning's n. Instead, only five classes of retardance need be remembered. When this system is coupled with the computation method to be described next, the advantages are many.

A diagram has been prepared for each retardance class which provides a direct solution of Manning's formula. The diagram for vegetations of Retardance E (very low retardance) is presented here, Fig. 4. With two of the three variables (R, S, and V) given, the third can be found directly by means of this diagram. Many diagrams have been prepared to aid in the solution of channel flow problems, but this is the only type which provides a direct solution with a variable retardance coefficient. Conservation channels are usually broad and shallow. They have their design flows in the range of most rapid change of n. If a very laborious trial and error solution is to be avoided such a graphical aid becomes a necessity. The usual problem in the design of conservation channels

TABLE 2. Physical Characteristics of Retardance Classes

Degree of retardance	Stand	Length of vegetation
A	Good	Longer than 30 in
B	Good	11 to 24 in
	Fair	Longer than 30 in
C	Good	6 to 10 in
	Fair	11 to 24 in
D	Good	2 to 6 in
	Fair	2 to 6 in
E	All	Less than 2 in

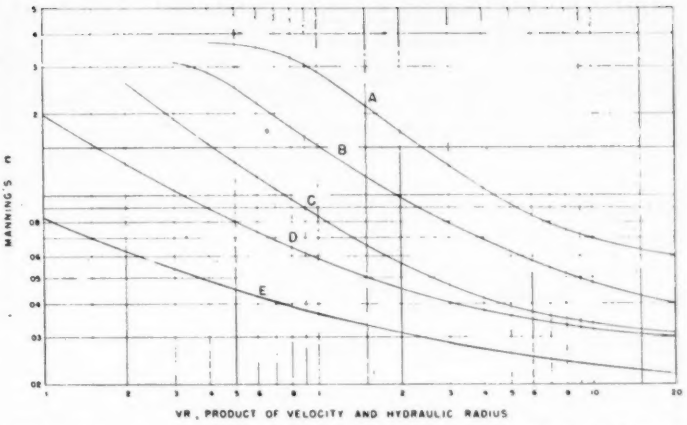


Fig. 3 Degrees of vegetal retardance for which graphical solutions of the Manning formula have been prepared

is the selection of channel shape and dimensions. The discharge rate, Q, and slope, S, are known. A vegetation to line this channel is chosen on the basis of both hydraulic and agronomic considerations. A design velocity, V, is selected. (The selection of a design, or permissible, velocity will be discussed in the section on protective characteristics). The retardance class of the vegetation is determined. Then entering a diagram such as Fig. 4 with the known S and selected V, the required R is determined directly. The necessary area of cross section, A, is readily computed by dividing Q by V. With both R and A given, the channel dimensions can be determined. This is done most readily by the use of diagrams which show the relationship between A, R, and channel shape and dimensions. The Stillwater hydraulic laboratory has prepared such diagrams but space or time limitations do not permit their presentation here.

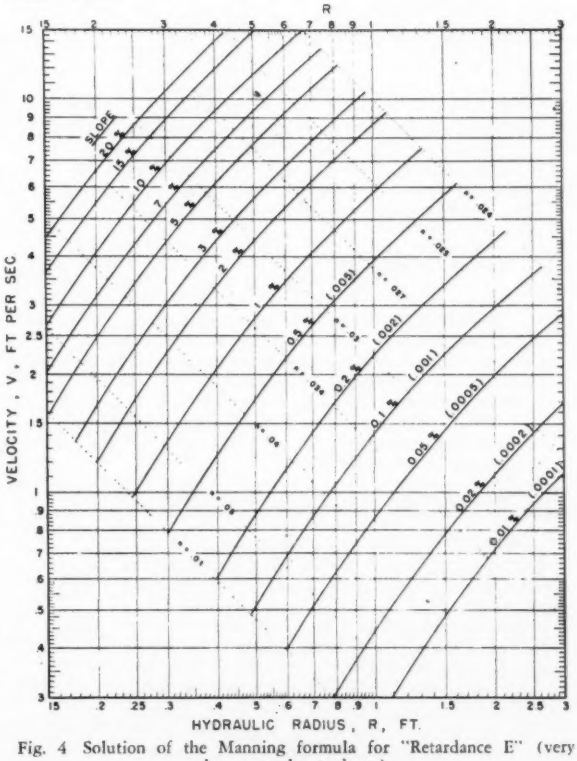


Fig. 4 Solution of the Manning formula for "Retardance E" (very low vegetal retardance)

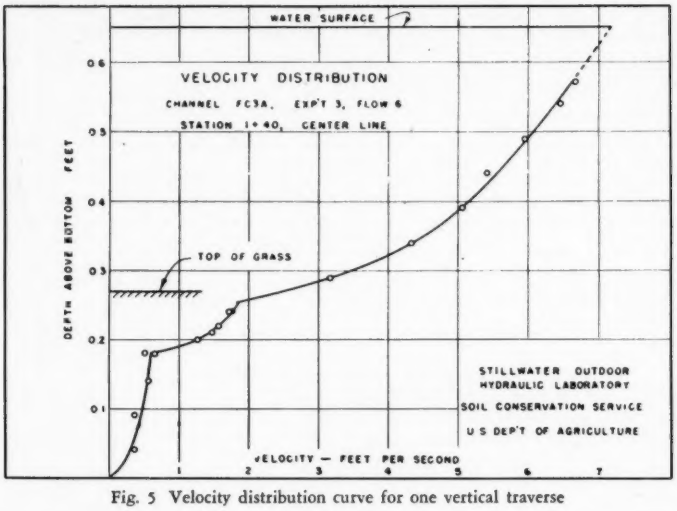


Fig. 5 Velocity distribution curve for one vertical traverse

TABLE 3. CLASSIFICATION OF VEGETAL COVERS ACCORDING TO RETARDANCE

Retardance	Cover	Condition
A	Weeping lovegrass	Excellent stand, tall, (avg. 30 in)
	Ischaemum (yellow bluestem)	" " tall, (avg. 36 in)
	Kudzu	Very dense growth, uncut
	Bermuda grass	Good stand, tall (avg 12 in)
	Native grass mixture (little bluestem, blue grama, and other long and short mid-western grasses)	Good stand, unmowed
B	Weeping lovegrass	Good, stand, tall (avg 24 in)
	Lespedeza sericea	Good stand, not woody, tall (19 in)
	Alfalfa	Good stand, uncut (avg 11 in)
	Weeping lovegrass	Good stand, mowed (avg 13 in)
	Kudzu	Dense growth, uncut
	Blue grama	Good stand, uncut (avg 13 in)
	Crabgrass	Fair stand, uncut (10-48 in)
	Bermuda grass	Good stand, mowed (avg 6 in)
	Common lespedeza	Good stand, uncut (avg 11 in)
C	Grass mixture — summer (orchard grass, redtop, Italian ryegrass, and common lespedeza)	Good stand, uncut (6-8 in)
	Centipede grass	Very dense cover (avg 6 in)
	Kentucky bluegrass	Good stand, headed (6-12 in)
	Bermuda grass	Good stand, cut to 2.5-in height
	Common lespedeza	Excellent stand, uncut (avg 4.5 in)
	Buffalo grass	Good stand, uncut (3-6 in)
D	Grass mixture — fall, spring (orchard grass, redtop, Italian ryegrass, and common lespedeza)	Good stand, uncut (4-5 in)
		After cutting to 2-in height
	Lespedeza sericea	Very good stand before cutting
E	Bermuda grass	Good stand, cut to 1.5-in height
	Bermuda grass	Burned stubble

Vegetal Protection Against Erosion. The most important property of a vegetation for vegetated waterways is its ability to protect the waterway from scour. This might be more properly called a structural rather than a hydraulic characteristic. However, it must be considered along with strictly hydraulic properties when a channel is designed. So this protective property is usually included with the hydraulic properties. The usual measure of the protective ability of a vegetation is the maximum velocity to which the vegetation can be subjected and still protect the channel from serious erosion. The testing procedure at the laboratory permits the determination of this property. Prior to a test flow careful measurements are made of the channel bed. After the flow has been turned out of the channel these measurements are repeated. In this way a measure of the depth of scour during the test is obtained. When the rate of this soil removal becomes excessive the permissible velocity is assumed to have been exceeded. The bed measurements are supplemented by visual observations to aid in this determination.

The permissible velocity for a vegetation will depend on the kind and quality of the vegetation and on the texture of the soil in the channel bed. Sod vegetations have the highest permissible velocities with very clumpy bunch grasses the lowest. Complete sods give complete protection to the channel bed, while bunch-type grasses have unprotected bare areas between the clumps. In addition considerable turbulence will take place around a large clump of vegetation which will cause considerable local scour. Channel slope has also been found to affect permissible velocity. The steeper the channel, the smaller is the permissible velocity. This may be due to the extremely turbulent flow in the very steep channels.

Permissible velocities based on these studies are given in Table 4.

The velocities given in Table 4 apply to good, uniform covers in uniform channels only. For conditions less good or uniform the permissible velocities should be reduced. Tests on one Bermuda grass channel with a small bare watercourse running its length indicated a mean permissible velocity of only 4 fps. This is only half that allowed for a good uniform cover. The velocities which existed in and around the bare section of the channel may have greatly exceeded 4 fps. Since velocities were not measured, there is no way of knowing. However, in ordinary channel design it is not practical to consider the velocity distribution in the cross section. The mean velocity is the only one that can be used.

Velocity Distribution. Some measurements of velocity distribution have been made in a grass-lined channel. The instrument used was a Pitot tube. With a small tube it is possible to get a complete traverse from channel bed to water surface. Fig. 5 is the velocity distribution curve obtained for one vertical traverse. Also shown on this figure is the top of the grass mat in the channel. This is a typical vertical velocity distribution curve for a vegetal channel. Apparent immediately are the low velocities in sections occupied by the grass. From the channel bed to near the top of the grass mat the velocities do not exceed one foot per second. At the upper surface of the grass mat the velocity starts to increase rapidly. From this point on the velocity distribution curve approximates that normally found in non-vegetal channels. A study of this diagram indicates why a vegetal lining protects a channel bed from erosion. Not only are the high velocities kept away from the channel bed, but the zone of greatest rate of change is at the top of the grass mat, and not at the channel bed where it normally occurs in non-vegetal-lined channels. This may be of importance. One theory on the detachment of soil particles from a channel bed attributed the detaching force to the steep velocity gradient at the channel bed causing an uplift on the soil particles. If this be the case then removing the zone of

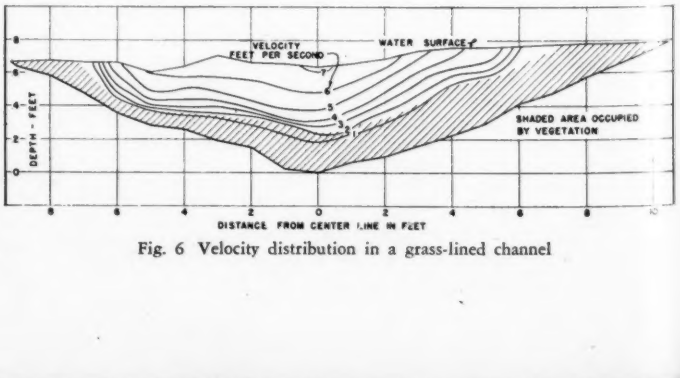

VELOCITY FEET PER SECOND
WATER SURFACE
SHADED AREA OCCUPIED BY VEGETATION
DEPTH - FEET
DISTANCE FROM CENTER LINE IN FEET

Fig. 6 Velocity distribution in a grass-lined channel

TABLE 4. PERMISSIBLE VELOCITIES FOR CHANNELS LINED WITH VEGETATION

Cover	Slope range per cent	Permissible velocity, fps: Erosion resistant soils	Permissible velocity, fps: Easily eroded soils
Centipede grass	0-5	9	7
Bermuda grass, good turf kept mowed	5-10	8	6
	over 10	7	5
Bermuda grass	0-5	8	6
	5-10	7	5
	over 10	6	4
Buffalo grass	0-5	7	5
Kentucky bluegrass	5-10	6	4
Smooth brome	over 10	5	3
Blue grama			
Grass mixture	0-5	5	4
	5-10	4	3
	(Do not use on slopes steeper than 10 per cent)		
Lespedeza sericea	0-5	3.5	2.5
Weeping lovegrass			
Ischaemum (Yellow bluestem)			
Kudzu	(Do not use on slopes steeper than 5 per cent, except for side slopes in a combination channel)		
Alfalfa			
Crabgrass			
Annuals, used on mild slopes or as temporary protection until permanent covers are established	05	3.5	2.5
	(Use on slopes steeper than 5 per cent is not recommended)		
Common lespedeza			
Sudan grass			

steepest velocity gradient from the channel bed should remove an eroding force. While on the subject of protection offered a channel bed, it might be mentioned that the roots are most useful in holding the vegetation in place.

A complete traverse was made of the velocity distribution in the channel cross section. Fig. 6 shows this cross section together with the lines of equal velocity. This diagram also shows the low velocities near the bed with the most rapid increase occuring at the top of the grass mat. In passing mention will be made of the velocity head and momentum coefficients since they were so extraordinarily high. The velocity head coefficient, α was 3.48 (velocity head $= \alpha\ [V^2/2g]$ and the momentum coefficient, β, was 1.70 (momentum $= \beta\ w/g\ AV^2$). These high values are to be expected when the far from uniform velocity distribution is considered. This information may be of value to those doing work requiring a more nearly correct value of the energy content of the flow.

Application to Design Problems. The foregoing has been a brief review of the hydraulic characteristics of vegetation in waterways. Suggestions will now be offered on how this information can be applied to conservation channel design problems.

A conservation channel must be built so that it will carry the design flood without overtopping or eroding. The first requirement is met by making the channel cross section large enough to contain the predicted flow. The second is achieved by selecting a channel cross section that will keep the mean velocity below the permissible.

In the case of a vegetated waterway this is not a simple problem. The complication is introduced by the variability of the hydraulic characteristics of the vegetation. Both the retardance class and the permissible velocity vary during the year because of the growth cycle and because of maintenance operations. A second complication is the weather. The expected flood flow may differ for each month in the year. With both the hydraulic characteristics of the vegetation and the expected flood flow varying with the time of the year, it may be difficult to select the critical or design periods. The maximum flow and the highest retardance may not occur at the same time. Thus in designing for capacity it may be unnecessary to use the combination of the extremes. The lowest permissible velocity and the maximum flood also may not occur at

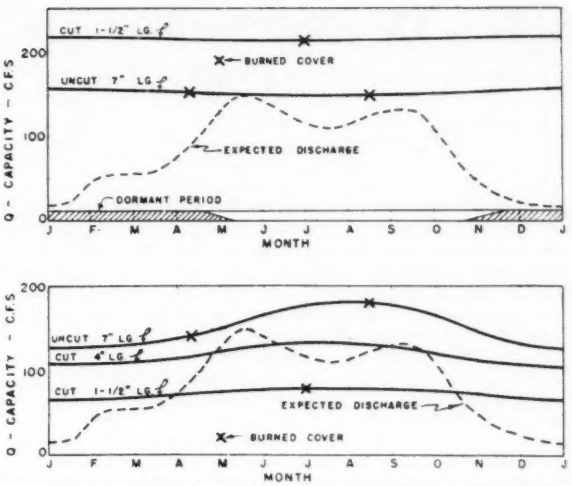


Fig. 7 The flow capacity of a Bermuda-grass-lined channel as influenced by season and maintenance practice: (A) (*Top*) Maximum possible capacity (capacity of channel if flowing full). (B) (*Bottom*) Maximum permissible capacity (capacity of channel if permissible velocity is not to be exceeded)

the same time. So a combination of these extremes may be unnecessary when designing for permissible velocity. What then are the critical design times? To answer this question a careful analysis must be made of the seasonal variation of the hydraulic characteristics and the runoff. How this can be done will be illustrated by a study of one of the channels at the hydraulic laboratory.

The channel to be examined is a Bermuda grass-lined waterway on a six per cent slope with a triangular cross section of side slopes one on ten. A hypothetical watershed has been assumed for this channel and the expected ten-year flood computed for each month of the year. This information is plotted on Fig. 7. It will be noticed that the peak discharge rate occurs in May with nearly as high a runoff to be expected in September. During the winter months very little discharge is anticipated.

The next step is to investigate the effect of the grass condition on the capacity of the channel. The maximum possible capacity of the channel for various cover conditions at different times of the year is shown on Fig. 7 A. It will be observed that when the grass is allowed to remain long the channel will have its minimum capacity. It will have a slightly lower capacity in the summer months than in the winter. Dormant vegetation seems to have slightly lower retardance coefficients than green vegetation of equal length and density. The critical design condition for capacity occurs in May with the cover left in an uncut condition. The channel has just sufficient capacity to meet the maximum flood flow. If the grass had been cut or burned off, the channel could carry a greater flow rate. However, then the permissible velocity probably would be exceeded.

The next step is to study the permissible velocity in the channel. This was done by computing the maximum permissible capacity of the channel. This is the flow rate the channel can carry without the permissible velocity being exceeded. When the grass is left long it will have the greatest resistance to flow. As a result it will take a higher flow rate to produce the maximum permissible velocity. Fig. 7 B indicates that it would take a discharge rate of 180 cfs before the water would be flowing at its permissible velocity. However, in this case the channel would be overtopped since its capacity at this stage of growth is only 150 cfs. If the grass were cut to a length of 4 in, the resistance to flow would be so reduced that the permissible velocity would be reached by a flow of only 130 cfs. Since the flow rate may exceed this at two different times in the year, it may be advisable to control the time of cutting the grass. Presumably if *(Continued on page 189)*

Development of Mechanical Equipment for Unloading Chopped Forage

By W. R. Peterson
MEMBER A.S.A.E.

IT IS perhaps impossible to say just when self-unloading wagons for chopped forage were first used, and it probably isn't important. There is a patent dated 1901 for a self-unloading freight car, another in 1903 for a grain wagon, and one in 1915 for a bundle wagon, besides many other specialized applications which have been patented. I believe it is quite safe to say that self-unloading forage wagons have become practical only as a result of field chopping of forages. It is to be expected that increased use of field-chopped forage and bedding should bring with it an increased demand for unloading devices.

As is so often the case, most unloading devices are compromises with existing wagons, and wagon design is still influenced by the old horse-drawn wagon. I cannot see any real reason for retaining the 4½-ft wagon tread. This width was quite logical when wagons were drawn by horses. It allowed the horses and the wheels to use pretty much the same track. It was sufficiently wide for reasonable stability under a one-ton load of hay. It allowed a fairly sharp turn, and rough roads and fields did not cause excessive side motion at the neck yoke.

Now, however, with automotive steering the excessive side motion is no longer a problem, and with most wagons now being tractor drawn the tread becomes of little significance except as wider treads give greater stability.

On the basis of the above analysis, I would venture a guess that we will soon abandon our present standard tread, as well as the standard bolster width of 38 in. It seems quite likely that wagons will become wider, and as they increase in width they will more readily accommodate some of the equipment which is gaining so rapidly in popularity.

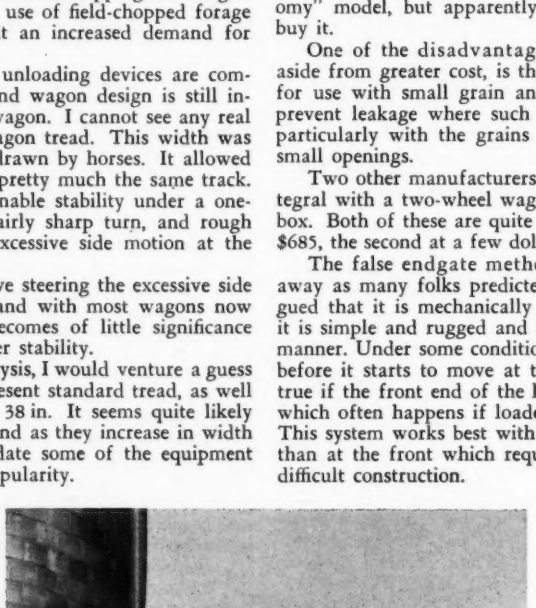
I have arbitrarily set up four classes of self-unloading equipment: (1) chain-and-slat conveyors, (2) false endgates, (3) canvas bottom, (4) tilting beds. These classes occasionally overlap but generally retain their separate identities pretty well. Proponents of each will argue vigorously for their own design and generally seem to hold all others in pretty low esteem. A rather hasty survey of this type of merchandise now being offered to the farmer reveals barely enough information to justify some rather casual observations.

The chain-and-slat conveyor follows closely the design of manure spreaders, with much the same type of chain and slats. Proponents of this design lean heavily on durability as their argument, and I believe it is quite sound. One manufacturer makes two types of chain unloader; one type with long slats, requiring a special wide-wagon design to accommodate it; the other a triple-conveyor design which will work with bolster stakes at standard spacing. This design has three separate chain conveyors, one to run in the space between the bolster stakes and one on either side running outside the bolster stakes. The cost of the latter is approximately double that of the first. This same manufacturer also offers a canvas unloader as an "economy" model, but apparently does not encourage farmers to buy it.

One of the disadvantages of chain-and-slat equipment, aside from greater cost, is the difficulty of sealing such a box for use with small grain and shelled corn. It is difficult to prevent leakage where such chains pass under the endgates, particularly with the grains which flow quite easily through small openings.

Two other manufacturers make similar equipment, one integral with a two-wheel wagon, the other one integral with a box. Both of these are quite expensive; the first lists at about $685, the second at a few dollars less.

The false endgate method of unloading has not passed away as many folks predicted it would. While it can be argued that it is mechanically inefficient, the fact remains that it is simple and rugged and it does the job in a quite reliable manner. Under some conditions the load hesitates quite awhile before it starts to move at the rear end. This is particularly true if the front end of the load is quite low and quite loose, which often happens if loaded from the front with a blower. This system works best with boxes or racks wider at the rear than at the front which requires special, but not particularly difficult construction.



The author says he is convinced that the capacity of a forage blower in tons per hour will never be fully used until the whole unloading job has been mechanized

One of the simplest methods of actuating a false endgate is by means of a second tractor. This method is both crude and erratic. An ordinary two or three-plow tractor is likely to experience some diffculty in moving a large load under the unfavorable conditions which will frequently be encountered when unloading in this manner. This method is somewhat hazardous due to difficulty of control and the long taut cables which are required.

A more common method, one that is more easily controlled, and certainly much safer, is to reel cables or chains on a rotating drum at the rear of the wagon. Pipe, which may vary from 1½ to 3 in inside diameter, is frequently used for the winding drum. Winding steel cable ¼ to ⅜ in in diameter on drums of this diameter violates all recommendations of the cable industry. While cable in such service is obviously flexed excessively in winding on such a small drum, it must be remembered that the number of cycles required is quite low, and it is not always this excessive flexing which will determine the life of the cable. I believe that

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1948, as a contribution of the Power and Machinery Division.

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weathering will determine the life of a cable more often than the actual service which is required.

Our experience has been that cable will not be dependable in its second year unless carefully protected from the weather from one season to the next. We used a 9/32-in cable, winding it on a 2½-in standard pipe.

Chain has also been used for this duty, but for some reason it does not seem popular. This is probably because of cost and bulkiness.

Canvas aprons or canvas wagon bottoms are at this time creating quite a stir. This system has many virtues but also many faults. With respect to efficiency, its proponents claim a great deal and there is no doubt much truth in their claims. The actual importance of this efficiency is however questionable. Almost any system will unload forage with a ½-hp electric motor, so there does not seem to be much point in arguing about efficiency. Canvas has the advantage of starting the load immediately, and it also tends to stretch the load rather than compress it. In cases of extremely heavy loads the canvas can be folded so as to remove a part of the load before the front part starts to move.

It is a difficult and time-consuming chore to get the canvas to stay in place on the wagon floor in windy weather. If it is allowed to blow around, it will frequently wind onto the roller in a peculiar folded fashion which always results in an oversize roll for which there may not be enough room, or in some cases it will cause the canvas to rip.

A FRONT-END FASTENING THE OBVIOUS ANSWER

The most obvious answer to this problem is a front-end fastening of some kind, generally some sort of a reel, to hold the canvas taut while loading. It is evident, however, that any front fastening of this kind cannot be reconciled with the folds in the canvas for the purpose of reducing the load on the canvas.

We have experimented with a single wide canvas as compared with twin canvases, each covering something less than half the width of the box. We have concluded that canvas life is much greater where twin canvases are used. If canvas does become displaced while loading or if some foreign object gets into the roll, the narrow canvas is quite tolerant of these hardships and will generally survive with no damage, while a wide canvas under similar circumstances is quite likely to fail.

The twin canvas design has a further advantage. It permits the use of a center bearing on the winding drum or pipe. Use of a center bearing allows the use of a much smaller pipe, a 1½-in pipe apparently being quite acceptable. This in turn reduces the torque required to move the load, and thus permits lighter construction in the driving mechanism, thereby reducing its weight and cost. Winding the canvas on a smaller drum also provides an accelerating characteristic through the greater increase in the diameter of the roll as the canvas is rolled up. This provides a greater canvas speed at a time when the load is generally not as deep as that part of the load which was first removed.

A disadvantage of the twin canvases is that of greater difficulty in keeping them in place in windy weather.

Tilting wagon beds do not lend themselves too well to the unloading of green forages. Green forages have a most aggravating tendency to move in a solid lump, and this only after the bed has been tilted to a rather steep pitch. Working on a tilted load to break it into smaller parts is extremely awkward and also quite hazardous. It is very difficult to stand on a tilted load and work below where you are standing. It is impossible to stand on a tilted wagon floor particularly when it is wet from green, chopped forage. For grain, ear corn, and dry chopped forage the tilting wagon bed is quite satisfactory.

Tilting wagon beds have sometimes been suggested in conjunction with other unloading devices, but this seems too extravagant to justify serious consideration.

Unloading devices are usually driven by ½-hp electric motors or by light gas engines of about 1½ hp. One-half horsepower seems adequate for almost any condition likely to be encountered provided suitable gear ratios are available.

Electric drills of ¾-in capacity have been used with good success by interposing a supplementary worm reduction between the drill and the winding drum. The drill finds many uses outside the harvest season and the cost does not seem to exceed that of other drives.

To the best of my knowledge no one has yet put on the market an unloading device to be powered from the blower, which would seem to be the most obvious source of power. We have done some work in this direction and have met with considerable success. It seems quite evident that something of this nature will ultimately appear on the market from some source but the design of unloading gear ought to stabilize somewhat to make such a device practical. A device of this nature would lack some of the flexibility of separate units. With a great variety of wagon attachments in use, plus a great variety of blowers, it would be quite a problem to set up a universal design capable of adapting any one of the wagon attachments to any one of the blowers.

Some manufacturers provide mechanical reverse gears for returning the conveyor after unloading. Others have devised beaters to eliminate all manual labor at the blower. I believe that this should be our ultimate objective. I cannot get many people to agree with me with respect to fully automatic unloading, but I still persist in believing that it can be done and that it will be done. If it is possible to eliminate one man at the blower, I believe it is also possible to eliminate the second one.

Our rather casual experience with a simple device of this nature has convinced me that the capacity of a forage blower in tons per hour will never be fully exploited until the whole unloading job has become mechanized. I am further of the opinion that very few of us fully realize how great a capacity a blower has if fed at a uniform rate.

With respect to cost, power units range in price from $94 to $200 without a source of power. The power source would probably range in cost from about $30 for a low-priced electric motor to about $100 for a light gasoline engine.

Wagon attachments are priced at $40 to $140 for canvas and false end-gate systems and $150 to $280 for chain conveyors. One complete two-wheel wagon is listed at $685, with beaters extra. A complete box is listed at $675 with chain conveyor.

Hydraulic Characteristics of Vegetation

(*Continued from page 187*)

the grass were cut in mid-June, it would grow enough in the summer to develop sufficient retarding properties to slow the September runoff to permissible speeds. If this channel were kept grazed very short the resistance to flow would be so low that the permissible velocity would be reached with a flow of only 80 cfs. Since the expected discharge rate will exceed this at all times during the growing season, it would not be advisable to graze the channel too heavily. If the cover is burned off, the permissible capacity drops to only 20 cfs. This is due to the great decrease in permissible velocity and to the decrease in the retardance coefficient. Obviously burning is not advisable for this channel.

It is not proposed that an analysis such as the foregoing be made for each channel. However, it is suggested that a study should be made of the runoff characteristics of the locality together with the seasonal characteristics of the vegetation in order to arrive at the critical design periods. Such a study will help indicate desirable and undesirable maintenance practices for waterways. Some such method seems to be the only rational approach to vegetal channel design and maintenance problems.

A Correction

THE author, Claude K. Shedd, has called attention to an error in his article, entitled "Progress in Methods of Drying Corn", in AGRICULTURAL ENGINEERING for March, 1949. The main heading for columns 2, 3, 4, and 5 of Table 1 on page 132 should read "Kernel moisture, percent wet basis" (not "dry basis").

Canons of Ethics for Engineers

Foreword

HONESTY, justice, and courtesy form a moral philosophy which, associated with mutual interest among men, constitutes the foundation of ethics. The engineer should recognize such a standard, not in passive observance, but as a set of dynamic principles guiding his conduct and way of life. It is his duty to practice his profession according to these Canons of Ethics.

As the keystone of professional conduct is integrity, the engineer will discharge his duties with fidelity to the public, his employers, and clients, and with fairness and impartiality to all. It is his duty to interest himself in public welfare, and to be ready to apply his special knowledge for the benefit of mankind. He should uphold the honor and dignity of his profession and also avoid association with any enterprise of questionable character. In his dealings with fellow engineers he should be fair and tolerant.

Professional Life

Sec. 1. The engineer will co-operate in extending the effectiveness of the engineering profession by interchanging information and experience with other engineers and students and by contributing to the work of engineering societies, schools, and the scientific and engineering press.

Sec. 2. He will not advertise his work or merit in a self-laudatory manner, and he will avoid all conduct or practice likely to discredit or do injury to the dignity and honor of his profession.

Relations With the Public

Sec. 3. The engineer will endeavor to extend public knowledge of engineering, and will discourage the spreading of untrue, unfair, and exaggerated statements regarding engineering.

Sec. 4. He will have due regard for the safety of life and health of the public and employees who may be affected by the work for which he is responsible.

Sec. 5. He will express an opinion only when it is founded on adequate knowledge and honest conviction while he is serving as a witness before a court, commission, or other tribunal.

Sec. 6. He will not issue ex parte statements, criticisms, or arguments on matters connected with public policy which are inspired or paid for by private interests, unless he indicates on whose behalf he is making the statement.

Sec. 7. He will refrain from expressing publicly an opinion on an engineering subject unless he is informed as to the facts relating thereto.

Relations With Clients and Employers

Sec. 8. The engineer will act in professional matters for each client or employer as a faithful agent or trustee.

Sec. 9. He will act with fairness and justice between his client or employer and the contractor when dealing with contracts.

Sec. 10. He will make his status clear to his client or employer before undertaking an engagement if he may be called upon to decide on the use of inventions, apparatus, or any other thing in which he may have a financial interest.

Sec. 11. He will guard against conditions that are dangerous or threatening to life, limb, or property on work for which he is responsible, or if he is not responsible, will promptly call such conditions to the attention of those who are responsible.

Sec. 12. He will present clearly the consequences to be expected from deviations proposed if his engineering judgment is overruled by nontechnical authority in cases where he is responsible for the technical adequacy of engineering work.

Sec. 13. He will engage, or advise his client or employer to engage, and he will co-operate with, other experts and specialists whenever the client's or employer's interests are best served by such service.

Sec. 14. He will disclose no information concerning the business affairs or technical processes of clients or employers without their consent.

Sec. 15. He will not accept compensation, financial or otherwise, from more than one interested party for the same service, or for services pertaining to the same work, without the consent of all interested parties.

Sec. 16. He will not accept commissions or allowances, directly or indirectly, from contractors or other parties dealing with his client or employer in connection with work for which he is responsible.

Sec. 17. He will not be financially interested in the bids as or of a contractor on competitive work for which he is employed as an engineer unless he has the consent of his client or employer.

Sec. 18. He will promptly disclose to his client or employer any interest in a business which may compete with or affect the business of his client or employer. He will not allow an interest in any business to affect his decision regarding engineering work for which he is employed or which he may be called upon to perform.

Relations With Engineer

Sec. 19. The engineer will endeavor to protect the engineering profession collectively and individually from misrepresentation and misunderstanding.

Sec. 20. He will take care that credit for engineering work is given to those to whom credit is properly due.

Sec. 21. He will uphold the principle of appropriate and adequate compensation for those engaged in engineering work, including those in subordinate capacities, as being in the public interest and maintaining the standards of the profession.

Sec. 22. He will endeavor to provide opportunity for the professional development and advancement of engineers in his employ.

Sec. 23. He will not directly or indirectly injure the professional reputation, prospects, or practice of another engineer. However, if he considers that an engineer is guilty of unethical, illegal, or unfair practice, he will present the information to the proper authority for action.

Sec. 24. He will exercise due restraint in criticizing another engineer's work in public, recognizing the fact that the engineering societies and the engineering press provide the proper forum for technical discussions and criticism.

Sec. 25. He will not try to supplant another engineer in a particular employment after becoming aware that definite steps have been taken toward the other's employment.

Sec. 26. He will not compete with another engineer on the basis of charges for work by underbidding, through reducing his normal fees after having been informed of the charges named by the other.

Sec. 27. He will not use the advantages of a salaried position to compete unfairly with another engineer.

Sec. 28. He will not become associated in responsibility for work with engineers who do not conform to ethical practices.

EDITOR'S NOTE: These "Canons of Ethics for Engineers", prepared by the Engineers' Council for Professional Development and adopted by that organization October 25, 1947, have been approved and adopted by the larger national engineering societies, and by a number of regional, state, and local societies as well. At the suggestion of the ECPD Committee on Engineering Ethics that the American Society of Agricultural Engineers likewise approve and adopt it also as its code of ethics, the ASAE Council has instruction the Secretary of the Society to publish the "Canons of Ethics" in AGRICULTURAL ENGINEERING for study and consideration by Society members. It is not the intention to submit the proposal for their adoption to a formal letter ballot of ASAE members, but if there are objections to their adoption, they should be sent promptly to the Society headquarters. If no serious objections are registered, in due course the Council will likely adopt them as the official code (or canons) of ethics of the Society.

A Development Relating to Agricultural Engineering in the Land-Grant Institutions

EDITOR'S NOTE: This report, prepared by L. L. SAMMET, associate professor of agricultural engineering, Purdue University, is based on discussions during a session of the College Division of the American Society of Agricultural Engineers, at the Society's winter meeting in December, 1948, and on statements of members of the special committee of deans of agriculture and engineering and of individual A.S.A.E. members.

A SIGNIFICANT resolution with respect to agricultural engineering was adopted at the annual meeting of the Association of Land-Grant Colleges and Universities in Washington, D.C., on November 9, 1948. The resolution is aimed at a sounder and more complete development of agricultural engineering curriculums in the land-grant colleges than exists at present. If properly implemented, it may prove to be a landmark in the development of professional agricultural engineering.

The resolution endorses a statement prepared by a special committee appointed by Dean Lampe, chairman, Resident Instruction Section, Engineering Division, ALGCU. This committee included Deans V. C. Freeman, J. H. Lampe, A. A. Potter, S. R. Shirky, and O. S. Willham. (Deans Freeman, Shirky, and Willham also constitute a subcommittee of the Organization and Policy Committee of the Resident Instruction Section, Agricultural Division, ALGCU, which has been studying curriculums in agricultural engineering). The special committee was appointed at the suggestion of Dean Potter. Dr. H. J. Barre acted as secretary of this special committee. In session at Purdue University in October, 1948, the committee drafted a preliminary statement which, after careful review, was submitted during the Washington meeting of the Association to the Resident Instruction Sections of the Divisions of Agriculture and of Engineering; there it was adopted by resolution, as an expression of policy by the agricultural and engineering deans. The resolution is as follows:

"RESOLVED that the principles approved by the Resident Instruction Sections of the Divisions of Agriculture and Engineering at their joint conference on Tuesday, November 9, 1948, be used as a guide in formulating curricula leading to degrees of Bachelor of Science in Agricultural Engineering and to Bachelor of Science in Agriculture with a major in Mechanized Agriculture, and that land-grant institutions which have sound programs of study leading to the B.S. degree in Agricultural Engineering apply promptly to the Engineers' Council for Professional Development for inspection and accreditation.

The essentials of the statement of principles incorporated in this resolution are (1) recognition of agricultural engineering as an important field of work, (2) recognition of two distinct types of curriculums — a professional engineering curriculum and a less technical curriculum in "mechanized agriculture", (3) advocacy of a sound program of graduate study, (4) adoption of a policy calling for the establishment of an accredited professional curriculum in at least 20 land-grant schools, and (5) endorsement of a policy of joint administration of the professional curriculum by agricultural and engineering deans. The preliminary statement of policy drafted by the special committee, and referred to above, is quoted in full as follows:

"The first curriculum leading to the B.S. Degree in Agricultural Engineering was established in 1904. At present, plans of study in agricultural engineering are being offered in about 30 land-grant colleges. Although the actual record of agricultural engineering is one of accomplishment, progress has not been as rapid as circumstances justify. The result is that to date the curricula in only three institutions and an option in a fourth have been accredited by the Engineers' Council for Professional Development, which accredits curricula for the engineering profession. The colleges of agriculture and the colleges of engineering in the land-grant institutions are in a position to render outstanding service to the agricultural industry of this country through complete co-operation in the development of suitable curricula for training young men in agricultural engineering and related fields. Unless we in the land-grant colleges and universities assign ourselves to this task, we have not met the challenge of service which our institutions must render to society.

"Agricultural engineering is unique in the degree to which it combines the need for work of a technical character, as in research and development in the state experiment stations and in industries serving agriculture, and work of a less technical character such as agricultural extension, farm advisory work, and farm management. This circumstance should be recognized in the organization of curricula in the agricultural engineering departments. Two distinct and complete curricula are recognized:

"1 *A Curriculum Leading to a B.S. Degree in Agricultural Engineering.* The *objectives* of this curriculum are to prepare the student for engineering service in rural communities; for teaching, research, and extension work with colleges, experiment stations, and governmental agencies in the fields which require engineering application; for positions in the manufacture and sale of farm machinery and farm power equipment; for advisory and managerial posts in connection with agricultural development; for positions with farm buildings and materials concerns, and for work relating to the increasing use of electricity in agriculture.

"The *courses* comprising this curriculum should emphasize the fundamentals of engineering and agriculture to provide the student with adequate technology to serve this industry. Briefly this requires mathematics through calculus, physics given to students in all engineering curricula, chemistry, mechanics, thermodynamics and fluid mechanics, and other basic subjects common to engineering curriculums; biology, soils, field crops, animal husbandry, and other basic courses in agriculture; general studies including humanistic and social sciences with special attention to written and oral English, and economics; and agricultural engineering subjects devoted to the engineering applications to agriculture which utilize the foundation courses in engineering and agriculture in advanced subjects taken in the senior year.

"2 *A Curriculum Leading to a B.S. Degree in Agriculture, With a Major in 'Mechanized Agriculture'* (farm equipment, farm buildings, farm water management, or rural electrification). This plan of study is for agricultural students who are interested in the production and primary processing of crops and livestock; in county agricultural agent and other extension work; in soil conservation work; and in sales and other work that deals directly with farm people. To an increasing extent, the operations on the farm are being mechanized through the use of power and machinery. Consequently the student enrolled in agricultural curricula must have an acquaintance with machinery, power, electrical equipment, soil conservation, farm buildings, and other agricultural engineering subjects that relate to production and processing. The *courses* covering these subjects should, therefore, be presented from the viewpoint of the user and consumer of farm equipment and not from that of engineering design.

"In addition to the above plans of study, there should be opportunity for students enrolled in engineering; for example, mechanical engineers, to elect courses in agriculture and agricultural engineering subjects, in order to acquaint themselves with the problems of the agricultural industry. Such election of courses ordinarily would not constitute a plan of study.

"In addition to undergraduate instruction, the land-grant college student must be afforded an opportunity for graduate programs in each of the above plans of study, leading to advanced degrees either in engineering or in agriculture.

"At the present time, it is not feasible nor desirable to offer two complete curricula at every land-grant college. There is urgent need, however, to increase the number of institutions at which a professional agricultural engineering curriculum is available and that all professional agricultural engineering curricula be accredited by the Engineers' Council for Professional Development. At least twenty institutions should offer an accredited curriculum.

"The question of administrative responsibility must be considered. A curriculum leading to a B.S. Degree in Agriculture with a major in 'mechanized agriculture' should be administered by the agricultural dean. Since close cooperation must be maintained between the department of agricultural engineering and the several agricultural and engineering departments, a curriculum leading to a B.S. Degree in Agricultural Engineering preferably should be jointly administered by the engineering and agricultural deans. The teaching staff may be on either the agricultural or engineering budgets."

As might be expected with respect to any statement of policy, many different points of view had to be reconciled in drafting the above resolution, and much difficulty was experienced in finding explicit and precise terms to express these views. A digest of views regarding several points of particular

difficulty is presented below. It should be stressed that any opinions expressed with respect to these points should in no way be attributed to the committee which drafted the above statement or be construed as representing the view of the Resident Instruction Sections of the Divisions of Agriculture and of Engineering of the Association of Land-Grant Colleges and Universities.

Is the policy intended to be rigid in its application? One interpretation of the resolution has been that it establishes a pattern which each land-grant school must follow. This view, however, is considered to be incorrect. The Association of Land-Grant Colleges and Universities has no means of enforcement, and in discussion of the resolution prior to its adoption there was no evidence that strict conformity was expected. On the contrary, the intention apparently was to establish a broad policy which could be implemented at each institution in whatever way is found most effective.

Is agricultural engineering unique in the degree to which it combines work of a technical character with work of a less technical or a service character? Some disagreement with the opinion on this point presented in the statement has been expressed. It has been said that in many other fields—agronomy, horticulture, mechanical and mining engineering, for example —this dual aspect of technical and vocational work exists to an equal, or perhaps greater, degree than in agricultural engineering. This issue could be debated at great length, with excellent arguments on both sides. Perhaps it is sufficient to recognize that a significant and important part of the work concerned with agricultural equipment and structures requires knowledge and experience of a vocational character, and that adequate means for training men to serve in this area should be available.

Is a dual curriculum desirable? Some objection has been expressed to the recognition of two types of curriculums—one curriculum leading to a professional engineering degree and a second leading to a B.S.A. degree with a major in "mechanized agriculture". It is argued that agricultural engineering already is handicapped by a lack of standards with respect to its curriculums and that professional development has been greatly retarded by the fact that prospective employers of agricultural engineers find it impossible to judge the qualifications of candidates whose training may range from "intensely practical" to "highly technical". Offering two curriculums of different technical levels is confusing and reacts to the disadvantage of the one of professional grade.

Another view, strongly supported by some agricultural deans, is represented in the resolution. This is that there are extensive areas of service in connection with agricultural equipment and structures for which a practical training is adequate and in some instances preferred. Unless curriculums are offered to meet this need, an opportunity for maximum service both to students and to agriculture will be missed. Fields of service for such graduates will be of a vocational character.

Another view is that in many schools now offering work in agricultural engineering, the present institutional development does not warrant the establishment of an accredited professional curriculum. Since existing curriculums in these institutions are not likely to be abandoned, it is preferable, therefore, that these curriculums be sharply distinguished from the professional curriculums, as is provided for in the resolution. This is perhaps the major advantage of the dual curriculum suggestion.

Must both curriculums be offered; would the curriculum in "mechanized agriculture" displace the present "service courses"? There appears no reason to believe that both curriculums need be offered; the appropriate answer depends on the need and resources at each school. It is important, however, that a curriculum be clearly and completely in one category or the other. There should be no "twilight curriculums.

Service courses will not be affected by the introduction of a curriculum in "mechanized agriculture". Students majoring in other branches of agriculture will continue to need instruction in farm mechanics and related subjects, and service courses not constituting a curriculum will be continued.

To what degree must the professional curriculum be jointly administered? The statement is intentionally broad on this point. The principle is recognized that the curriculum in agricultural engineering should be of concern to deans of both agriculture and engineering. The details of joint administration involve complicated relations in matters of organization, facilities, staff, finance, and, occasionally, personalities. The vital consideration is that the curriculum secure interest and support from both engineering and agriculture; experience with joint administration in several institutions has shown that an open-minded approach readily resolves any complications.

What is the value of the resolution? It is important to recognize that the statement of policy and the resolution in themselves can accomplish very little. Their greatest value is as incentives to those interested in advancing the professional standards in agricultural engineering and in improving its service to agriculture through assuring the highest possible standards of instruction to its students.

Improving Advice to Farmers

(Continued from page 167)

Several farmers were shown performing "stoop" labor, and in various uncomfortable, ineffective, and dangerous positions, as a matter of course, in accomplishing results which might be desirable if the cost were not prohibitive. As occasional operations, the methods and risks shown might be satisfactory, but as efficient production routines they are hangovers from the horse-and-buggy age. We just don't like to see them taken for granted as necessary or desirable. We don't like to see that low a value placed on human life and human time.

One farmer was shown tending a brooder stove with one of those pint-size ash shovels which seems to be standard equipment for small stoves. This shovel may be in keeping with man's one-eighth horsepower manual labor capacity, but we question its suitability as equipment for tending the "eternal fires" of the spirit of progress.

Something captioned as "a modern completely equipped machine shop" appeared in the picture to be poorly lit, completely lacking in use of paint to promote safety, and tending toward the more common haphazard arrangement of equipment, tools, supplies, and work in progress.

Some mysterious lingering nostalgia for cutting and shocking corn by hand at any cost is suggested by a picture showing a farmer using a modern rubber-tired tractor and manure loader to load corn shocks upright on rubber-tired wagons. Apparently his farm is sufficiently mechanized to handle the cutting job by machine if desired. We wonder how many corn belt farmers want or can afford to hold back on mechanizing the cutting operation for old-times' sake.

A labor-saver for livestock, but lacking in similar consideration for the farmer, is a roofed-over, side-feeding, end-loading hay feeding rack. Conceivably some arrangement could be made for filling it easily, but as pictured it looks like a dusty, cramped, hand-fork, manual labor, tonnage-moving proposition which could scarcely be justified except as conditioning exercise for a football player.

A concrete feeding block for 100 or more hogs is shown being supplied with feed by one man carrying feed in a 5-gallon bucket and bending at the hips to empty it. Possibly he has help not shown in the illustration, to enable him to get the feed to the block by this method fast enough to keep the hogs from starving.

The best that can be said for several of these pictures is that, in addition to showing some desirable setup or operation, they show only one man working at a needless disadvantage.

Probably we have been similarly guilty of using some pictures illustrating one or more insupportable practices, along with the advocated method explained in the caption. Apparently it is as difficult to get all the "bugs" out of farm practice recommendations and pictures as it is to get them out of engineering designs. But a little broader look at some of these recommendations and pictures before they are published might result in substantial improvement.

Practical Methods of Water Application

By Ivan D. Wood
MEMBER A.S.A.E.

SINCE the beginning of civilization, irrigation in one form or another has been practiced for the production of food and fiber. Practical methods of water application have been a problem since the beginning and a complete solution has not yet been effected. Inability to apply water properly has caused undue loss in crop production, in top soil and in land which has become waterlogged and ruined with alkali salts.

Site Conditions Determine Method. A complete appraisal of site conditions is necessary to determine a suitable method of water application. This appraisal will require the use of a topographic map, a soils map, a land classification map, knowledge as to the quantity and quality of water available, and the kind of crops to be grown.

On fields with relatively little slope a contour interval as close as 0.2 ft may be necessary since slight changes in the surface elevation may result in very uneven application. The use of a soils map and a land classification map is necessary to determine a system of land use which will conserve the surface soil and still permit irrigation water to be applied without excessive labor.

The method of application used will depend somewhat upon the quantity or head of water available. If the water contains soluble salts or considerable quantities of silt, the method used may be different than that employed where the supply is pure and clear. Naturally the kind of crops to be grown affect the method of water application considerably. Land permanently planted to close growing crops, as pasture and hay, may have considerably more slope than that planted to row crops without fear of excessive erosion.

An appraisal of site conditions may indicate that extensive land preparation is required. In some cases the surface may need only smoothing with a land plane, or it may be necessary to change the entire topography with heavy earth-moving equipment. In cases where an uneven or irregular surface requires too much expense in leveling, then sprinkler irrigation may be indicated. Often the topography is suitable for surface irrigation, but the soils are so light and absorb water so readily that the use of the sprinkler is the only practical solution.

It is evident, from what has been said, that considerable experience is necessary on the part of the irrigation engineer to appraise site conditions and determine the most practical method of surface treatment and water application to use.

What Constitutes Good Water Application. Good water application results in a uniform distribution of moisture through the root zones of the plants to be grown. Up to the present time no perfect system has been devised which is effective under all conditions. When water is flooded over the surface, soil near the source of supply becomes deeply saturated while that further away will receive less and less moisture until finally the amount is insufficient for proper plant growth. In the case of sprinkler irrigation it has been found that some areas are rather deeply saturated while others may receive very little moisture. The sprinkler pattern is greatly affected by wind and other factors.

In order to determine a suitable method of water distribution, some knowledge must be had of the rate at which the soil will absorb moisture. Tight clay soils may be capable of taking only ⅛ to ¼ in per hr without runoff, whereas sandy soils can absorb water at rates in excess of 2 in per hr. Water-holding capacity of soils is important. Some soils will hold available for plants 2 in of water per foot of depth while others may retain less than ¾ in per ft of depth. The latter soils require frequent, light irrigations while the former should receive heavier and less frequent applications. In order to determine what constitutes good water application, some knowledge of the water use by plants is necessary. Some require heavy applications of water at frequent intervals, others, such as the sorghums, will stand dormant for rather long periods and use irrigation water whenever it can be applied.

In some areas good water application consists in covering the land surface, at times, with heavy applications to wash the soluble salts into the deeper soil layers. Thus the total amount of water applied during a crop season may be several times that which would be needed in normal practice.

Head Control. After site conditions have been appraised and knowledge gained as to the water-holding capacity of the soil, the rate at which the soil will absorb water, and the type of plants to be grown, it is necessary to decide upon a method of application best adapted to the particular field in question. It is now considered very important to apply water in such a way that erosion of the surface soil is prevented and water is not wasted. Often heavy applications of water to light soils may carry away soluble plant food elements beyond reach of plant roots.

Control of the amount of water applied or "head control" is extremely important in irrigation practice. Uncontrolled water application has resulted in thousands of acres of land being eroded beyond repair and untold acre-feet of water being wasted. Often those water users with prior rights use several times the amount actually needed for crop production. In some areas the water user has a perpetual flowing right, meaning that he can divert a certain amount of water during the entire year whether needed or not.

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1948, as a contribution of the Soil and Water Division.

IVAN D. WOOD is irrigation engineer, Soil Conservation Service, U. S. Department of Agriculture (512 Insurance Bldg., Denver 2, Colo.).

Fig. 1 (*Left*) Uncontrolled flows of irrigation water cause serious erosion • Fig. 2 (*Right*) Good water distribution is seldom possible unless the land surface is well prepared by leveling

It is significant that irrigation water is carefully controlled from the large reservoir to the canal, from the larger canals to the smaller ones, and finally to the farm headgate. In many cases, from the farm headgate to the field and across the land control is imperfect resulting in waste, erosion, waterlogged soils, and soils so heavily impregnated with alkali that crop growth is impossible.

In irrigation of row crops head control is accomplished in some instances by the use of spiles or small tubes placed through the ditch bank. These tubes were formerly made by nailing 4 lath together but now may be purchased in aluminum or galvanized iron, or in plastic or flexible rubber. Spiles are manufactured in sizes from ¾ to 2 in or more in diameter. Some are fitted with gates permitting a close control of the flow. Spiles may be placed in a secondary ditch or "distribution bay" which is fed from the main field ditch by means of a control box. If the spiles are carefully set at a uniform grade, the flow to each row may be carefully metered by regulating the control box, or "take-out box" as it is often called.

In recent years, siphon tubes have come into general use over most of the irrigated west. The siphon is simply a curved pipe placed over the ditchbank which operates on the well-known siphon principle. These tubes are manufactured in many shapes and sizes and may be had in aluminum, galvanized iron, plastic, or flexible rubber. Sizes vary from ¾ to 2 in in diameter and some are provided with gate controls. The flow of the siphon is regulated in a number of ways. Discharge can be varied somewhat by changing the "head" or height of the water in the ditch above the end of the tube. Some tubes are provided with control gates. Most operators, however, prefer to use a tube size adapted to the flow desired. It has been found that the 1-in or 1½-in tube is adapted for most conditions. Where more water is required two or more tubes may be used per row.

There is a tendency at the present time toward the use of gated-surface pipe, made of galvanized iron, aluminum, or canvas. This pipe is made in sizes from 3 to 12 in in diameter and is provided with adjustable gates spaced according to the row width to be irrigated. At the present time, gated pipe is becoming popular in many western states. When made of aluminum, it is light, quickly connected, gives excellent head control, and may be used in place of ditches to a large extent. A number of companies are manufacturing canvas pipe which is also provided with gates or openings after the manner of the metal pipe. Canvas pipe is somewhat cheaper and when treated by some of the new methods is largely immune to rotting and molding. Good head control can also be provided by the use of wooden, concrete, and metal troughs which are laid along the upper end of a field temporarily or built in permanently. These troughs or flumes are actually lined ditches which may be so arranged that water will flow over one edge in a thin sheet for the irrigation of close-growing crops such as pasture, hay or grains, or may be distributed through properly spaced holes or gates for row crops.

Application rate for sprinkler systems is accomplished by changing the size of the nozzle, or by overlapping sprinkler patterns.

Distribution Methods. The oldest, simplest, but often most inefficient method of water distribution is known as "wild flooding". As the name implies is consists of cutting the ditchbank and allowing the stream to flood over the land surface. This method has been used through all time and in all countries to the detriment of irrigation practice.

For application to close-growing crops, four or five common methods are in use. For land with irregular surface and considerable slope the contour ditch is a practical and fairly efficient means of application. Plow furrows or small ditches are carried across a slope on the contour, or if of considerable length with a slight fall, perhaps 0.1 or 0.2 ft in 100 ft. In some cases water is taken from the contour ditch to a plow furrow on the lower side through a control box and then distributed over the surface from the furrow. This permits of careful control and on uniform land surfaces gives good distribution. The "border" method or "border dike" method consists of dikes carried up and down the slope, the head of water being controlled on the strip of land between dikes. This method is well adapted to gentle slopes and smooth land surfaces.

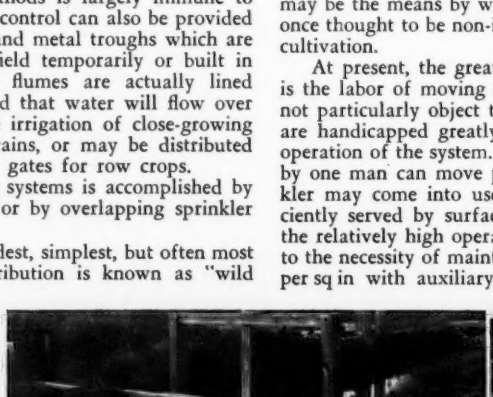
A third method, which has gained considerable prominence, is known as the "border ditch" method and consists in watering from ditches carried down the slope at intervals of 20 to 60 ft. The irrigator blocks the ditch with a check dam and floods land immediately adjacent. This method has many disadvantages, however. Where the ditches have considerable fall, there is a tendency to erode deeper at the upper end and to fill at the lower. The banks offer opportunity for weed growth, harbor insects, and consume a considerable portion of the field area. In addition, full time attendance of the irrigator is required.

Furrow irrigation is accomplished by conducting a flow of water in furrows adjacent to growing plants. The so-called corrugation method consists in making a series of small furrows spaced from 18 to 36 in apart by means of a sled arrangement or by a series of shovels followed by packer wheels. With good head control the corrugation system is successful on steep slopes and is sometimes used on close-growing crops where the surface is irregular and will not permit the use of other systems.

For corn, grain, sorghums, peas, beans, and many other plants, the irrigation water is carried down between the rows in furrows, the head being controlled as has been described elsewhere. A variation of this system consists in so-called "bedding" where one furrow actually irrigates two rows of plants. Furrow irrigation may be employed on either level or sloping land. On level ground, furrows may be quickly filled to a given depth and the water allowed to percolate into the subsoil.

The use of sprinkler irrigation for all types of crops has increased greatly during the past few years. This type of application is particularly adapted to hilly, irregular topography or to soils which absorb water rapidly. Some irrigation farmers prefer it on extremely level fields where surface application is difficult. It would seem that sprinkler irrigation may be the means by which many thousands of acres of land once thought to be non-irrigable may be brought into intensive cultivation.

At present, the greatest drawback to the use of sprinklers is the labor of moving the pipe. Many irrigation farmers do not particularly object to the original money outlay, but they are handicapped greatly in obtaining labor for the everyday operation of the system. If a method can be developed whereby one man can move pipe rapidly and efficiently, the sprinkler may come into use on lands which are now more efficiently served by surface irrigation. Some farmers object to the relatively high operation cost of the sprinkler systems due to the necessity of maintaining a pressure of from 35 to 100 lb per sq in with auxiliary pumping outfits. Some of the low-



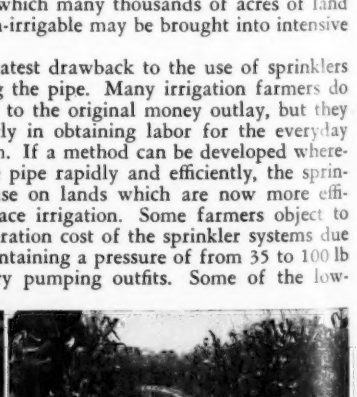


Fig 3 (*Left*) Control and measurement of the flow in irrigation ditches is important in modern irrigation design • Fig. 4 (*Right*) Irrigation of corn with plastic syphon tubes. Water is distributed to each row by syphon action from ditch to ground surface

pressure systems are very satisfactory where the soil will absorb water at the rate of one inch or more per hour. With the coming of cheap electrical power it may be possible to provide electrically operated pumps directly connected to motors. If electric power can be made available at a number of points on the farm, this would permit the use of a portable electric pumping unit which could be moved along the stream or irrigation ditch. Electrically operated pumping units require less overhaul and have a much lower rate of depreciation than those operated by other types of power.

A method of irrigation used in some areas is known as "subbing". This system consists of raising the water table to a point just below the root zone by applying large quantities of water through field ditches. In general it may be said that this method is uneconomical of water and often results in areas lower down the slope being waterlogged and ruined from alkali salts.

General Considerations. The method of water distribution is closely related to the topography, the soils, the plants to be grown, and the head and quality of water available. It is also indirectly related to the type of transportation system; that is, whether the water is conducted to the field through pipe or lined or unlined ditches. Where the transportation system consists of underground pipe, it is often possible to use the gated-surface pipe as a means of head control and to use contour or graded furrows as a means of water distribution. There are areas in the west where the water supply is extremely short during all or part of the growing season. By the use of pipe and graded furrows or by bench leveling it is possible to effect great economy in water use and increase crop production at the same time.

At the present time the unlined irrigation ditch is in bad repute. In fact, it is passing out of the picture in many areas and is being replaced by either lined ditches, underground or surface pipe, or a combination of these features. Recent research work indicates that water losses from unlined ditches may run as high as 10 to 16 per cent per thousand feet of length. There is also loss from evaporation and transpiration from plants growing on the banks. Ditchbanks are often infested with weeds, the seeds of which fall in the water and are transported to fields. In some instances as much as one-tenth of the entire field area is wasted because of ditches, spoil banks, and other unused areas resulting from their use.

DESIGN FOR IRRIGATION TO BEST ADVANTAGE

New irrigation projects are being designed so that various farm units are adapted to the topography. Instead of using the General Land Office method of subdivision using sections, quarter sections, etc., the farm units are designed to irrigate to the best advantage taking into consideration topography and soils. By careful land classification the farm unit can be divided into fields where cultural and cropping practices will prevent erosion and assist in maintaining soil fertility. Some new projects are now being designed and built in which the entire distribution system consists of underground pipe and where sprinklers or gated-surface pipe will replace all other forms of water distribution.

It is probable that many irrigation projects of the future will be designed with lined ditches or pipe transportation systems. Field distribution will undoubtedly be accomplished by careful molding of the land surface for the use of borders or furrows or by the use of sprinklers. Consideration is also being given to carrying the main distribution canal at lower levels and allowing it to act not only as a distribution feature but also as a drainage ditch. Water is then pumped to the higher levels for each individual unit or for groups of units.

The development of new type machinery for harvesting irrigated crops has affected methods of water application to a considerable extent. Beet harvesters, for example, work much more efficiently on land the surface of which has been leveled. Many modern machines operate much more efficiently on smooth even field surfaces. Since it is necessary to modify the field surface for the efficient use of machinery, it is often economical to use surface irrigation methods. Attention is also being directed to the fact that modification of the field topography greatly improves surface drainage and water application at the same time.

Attention has been directed in recent months to the shortage of water supply in many sections of the United States. Ground water supplies are diminishing rapidly in certain regions, the water of many rivers is overappropriated, and at the same time interest in irrigation is at an all-time peak and irrigation is no longer confined to the 17 western states. It is spreading rapily eastward where rainfall was once considered sufficient for maximum crop growth. Research has shown, however, that additional water together with commercial fertilizers and barnyard manure may produce greatly increased crop yields. In the west the entire economy of some states is dependent upon a sustained water supply. The signing of water compacts by officials of the various states is not a solution to the problem if the total supply is insufficient.

The time is past when uneconomical methods of water application can be used. It is impractical from every standpoint to apply water in large quantities upon poor soils with a low productive index at the expense of areas where many times the production could be obtained. A great many thousand acres of otherwise productive land have been ruined by waterlogging and alkali due to impractical and uneconomical methods of water application.

Agricultural Engineering Serves the Tourist and Resort Industry

By C. A. Gunn

LATE in 1945 the Tourist and Resort Service of Michigan State College was established with a phase assigned to the department of agricultural engineering. One of the first chores of this section was the setting of goals and organizing a program to attain them. Both research and extension were involved since there appeared to be many unknown factors in the design of tourist facilities and the goal of introducing improved tourist accommodations might best be reached through extension methods.

In an effort to map the course for this section, the need of a classification of subject matter became apparent. Adequate filing of reference material, illustrative material, and identification of new material to be published could not be had without some means of classification. Because the agricultural engineering department of Michigan State College for many years had numbered its drawings according to the agricultural engineering subject matter classification, there appeared to be logic in following this scheme with new additions to the drawing file.

It is doubtful if the original committee or individuals who developed this classification in 1925 anticipated a tourist and resort service. However, the subdivision 11.794, entitled "Tourist and Camp Structures", became the parent for the classification of tourist and resort information. With this beginning, the classification was well on its way. With a few months in the field, together with the accumulated background of others and some paper research, there appeared to be eight major groupings that needed attention in the program sooner or later, namely, (1) administration buildings, (2) car service buildings, (3) housing structures, (4) feeding structures, (5) miscellaneous buildings, (6) facilities, (7) utilities, (8) construction details, and (9) miscellaneous. Certainly we would need plans, sketches, and ideas regarding floor plans, exteriors, and interiors. The major structures for the tourist industry seem to be divided into overnight housing for transients, housing for vacationers at their resort destinations, feeding structures, and related structures supplementary to the main vacation activities. As on the farmstead, the planning could not stop at the front door and there would be need for information on the arrangement of buildings, sewage disposal, water supply, parking, and drives.

After several revisions, which will continue as new needs make themselves known, further subclassification under the base number 11.794, was accomplished. It has been recommended for inclusion in the revision of the agricultural engineering classification which is being made by a committee of the American Society of Agricultural Engineers.

In effect, this classification has almost become a plan of work. Demands from the field have largely determined the emphasis. For example, the demand for plan ideas for overnight cabins, motels, cottages, and resorts has indicated that a priority should be given this work. As more information is prepared in order to satisfy these needs, other supporting information will be given greater attention.

(Continued on page 200)

C. A. GUNN is assistant professor of agricultural engineering, Michigan State College, East Lansing.

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NEWS SECTION

A.S.A.E. Meetings Calendar

April 15 and 16 — SOUTHWEST SECTION, Grim Hotel, Texarkana, Tex.

April 15 and 16 — VIRGINIA SECTION, Hotel Roanoke, Roanoke

April 30 — MICHIGAN AREA SECTION, Hart Hotel, Battle Creek

May 13 and 14 — PENNSYLVANIA SECTION, Agricultural Engineering Bldg., Pennsylvania State College, State College

May 20 to 22 — TENNESSEE SECTION, Smoky Mountain Lodge near Knoxville.

June 20 to 23 — ANNUAL MEETING, Michigan State College East Lansing.

October 6 to 8 — PACIFIC NORTHWEST SECTION, Harrison Hot Springs Hotel, Harrison Hot Springs, B. C.

December 19 to 21 — WINTER MEETING, Stevens Hotel, Chicago, Ill.

ASAE Officers for 1949-50

AS A result of the regular election of officers of the American Society of Agricultural Engineers conducted recently by letter ballot, the following have been elected and will take office at the close of the Society's annual meeting to be held at East Lansing, Michigan, in June.

President — Frank J. Zink, consulting agricultural engineer, Frank J. Zink Associates, Chicago, Ill.

Councilors (3-year term each) — Fred A. Kummer, head, agricultural engineering department, Alabama Polytechnic Institute, Auburn, and K. W. Anderson, research engineer, Deere & Co., Moline, Ill.

The new Council of the Society for the year 1949-50 will include the above-named officers, together with the following:

G. A. Rietz, and A. J. Schwantes, past-presidents; E. D. Anderson, W. W. Weir, C. J. Scranton, and D. G. Carter, councilors.

The newly elected Nominating Committee of the Society consists of O. C. French (chairman), R. M. Merrill, and W. E. Meek. Members of the Society are invited to send any member of the Nominating Committee such suggestions as they may have for nominees for the election of officers of the Society in the next annual election of officers, to be held early in 1950. It is desirable that such suggestions be made to the Nominating Committee on or before June 1, 1949.

Fenton New Chairman of Mid-Central Section

NEW officers of the Mid-Central Section of the American Society of Agricultural Engineers, elected at its meeting March 18 and 19 at Manhattan, Kansas State College, are F. C. Fenton, chairman; Elmer F. Clark, C. W. Smith, and A. W. Zingg, vice-chairmen; and L. W. Hurlbut, secretary-treasurer. L. F. Larson and Dwight D. Smith were named as the new nominating committee. The officers took over their duties at the close of the meeting.

The Section also voted to hold its next meeting during the spring of 1950 at the University of Nebraska.

A change from the announced program for the Manhattan meeting was the appearance of Harold Halter, associate editor, "Farm Equipment Retailing", for Paul M. Mulliken, on the subject "Power and Machinery in Agriculture." Lester F. Larson provided, as an added program feature, a discussion of the meaning and use of Nebraska Tractor Test data.

Research projects covered in the scheduled tour of inspection during the meeting included the experimental heat pump installation, the wind erosion project, an experimental grain drier, a self-propelled two-row ensilage harvester, spraying equipment, and heat transfer through dairy barn floor materials.

Approximately 40 agricultural engineering students representing the ASAE Student Branches in Kansas, Missouri, and Nebraska, held a separate session in conjunction with the Section meeting. They were addressed by Arthur J. Schwantes, president of ASAE, and by Lee M. Ford, chairman of the Committee on Student Branches. Several of the students presented special reports.

Officers elected by the student group, to further their activities as an auxiliary of the Section, were Al McKelvie, Nebraska, chairman; Marne Karlin, Kansas, secretary-treasurer; and vice chairmen Burt Curry, Nebraska; Al Nitshke, Missouri; and Gene Bingston, Kansas.

Preliminary steps were taken by the group to develop a student paper competition within the three Branches represented.

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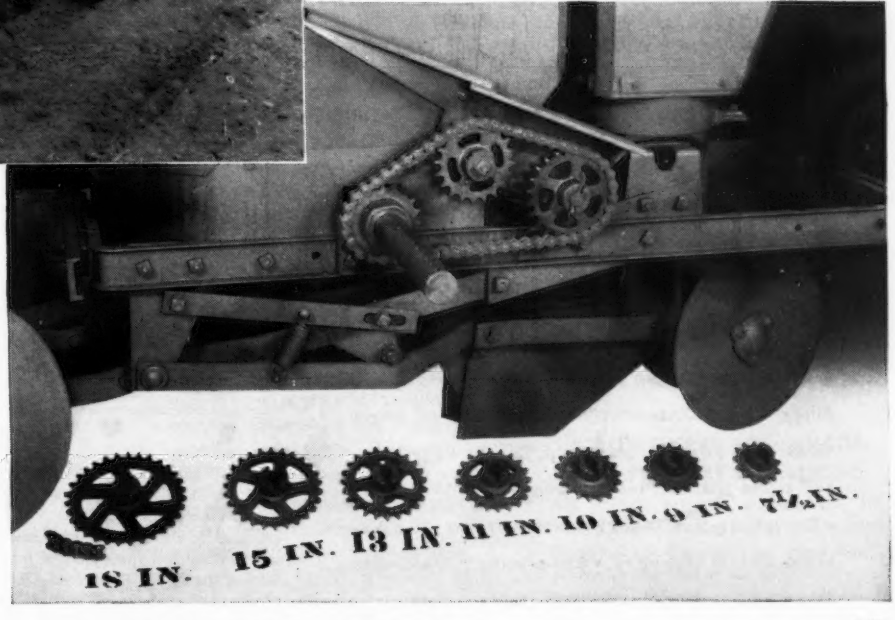

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To meet row-crop spraying equipment requirements, Tuthill offers the Model 5-W pump—a compact, dependable unit with advanced features that make it outstanding in weed and pest control service. Consider these important advantages:

• Direct mounting on power take-off • Adaptable to pulley drive • Close-coupled design. Over-all dimensions: 4½ x 5½ x 6⅜; net weight, 12½ lbs • Fits 1⅛" or 1⅜" spline shafts • Pressure range from 0 to 150 p.s.i. • Delivers 5 g.p.m. at 100 p.s.i. at 550 r.p.m.; 16 g.p.m. at 100 p.s.i. at 1750 r.p.m. • Self-priming . . . self-lubricating • Built of highly corrosion-resistant materials to handle a wide variety of spray liquids

Write for complete details today.

TUTHILL PUMP COMPANY
939 East 95th Street, Chicago 19, Ill. Phone: REgent 4-7420

Personals of A.S.A.E. Members

William Black has resigned as assistant manager, flame cultivation division, New Holland Machine Co., to accept a position in the purchasing department of The Oliver Corp., Chicago.

Harold L. Brevick, formerly connected with the Creamery Package Mfg. Co. in sales work, is now employed as draftsman in connection with the design of reverse-cycle heating units by the West Coast Trade Institute, Portland, Ore.

Roy B. Gray, chief, farm machinery division (BPISAE), U. S. Department of Agriculture, has been awarded the decoration "Officier du Merite Agricole" by the French Minister of Agriculture, in recognition of his services to agriculture.

Keith H. Hinchcliff, extension agricultural engineer, University of Illinois, was a featured speaker on the farm forum program, March 11, sponsored by the Minneapolis Chamber of Commerce. His talk was on rural homes, rural housing, construction and remodeling. He was also a member of a panel discussion on rural living conditions.

W. S. Hockey, recently resigned as assistant chief designer of agricultural machinery, Deming & Co., to accept employment as implement project engineer by Harry Ferguson, Ltd., of Coventry, England.

Allan R. Hunsicker has recently been advanced by the New Holland Machine Division of The Sperry Corporation to the position of senior buyer and assistant to the purchasing agent. He was previously engaged in work having to do with the control of material and inventory for his company.

Edwin L. Miller recently resigned as a member of the agricultural engineering staff of Purdue University to accept employment as a regional supervisor of products education, Harry Ferguson, Inc.

Paul J. Newton, formerly treasurer and general manager of Hertzler & Zook Co., is now chairman of the board of Keystate Mfg. Co., Lewistown, Pa.

Harry B. Pfost has resigned as assistant professor of agricultural engineering, Alabama Polytechnic Institute, to engage in farming near Cowgill, Mo.

A. M. Powell, Jr., a 1947 agricultural engineering graduate of the University of Georgia, is now employed as public health engineer for the Georgia Department of Health. He will be engaged on dairy inspection work with the state mobile milk laboratory.

Floyd W. Reuter, until recently a trainee in the engineering departmen of Harry Ferguson, Inc., has recently been made field test engineer on farm machinery for his company.

Ray M. Ritchie, Jr., recently resigned as draftsman in the engineering department of the Southern States Co-operative, Inc., to accept appointment as agricultural engineering extension specialist, specializing in farm buildings, with the North Carolina Agricultural Extension Service, Raleigh.

Reginald L. Vassar, recently associated with the Rural Electrification Administration, USDA, is now employed as an engineer designing integral horsepower motors in the motor engineering division, General Electric Co. at the River Works at Lynn, Mass.

Albert N. Wold, formerly connected with the agricultural machinery division of Diamond Iron Works and Mahr Mfg. Co., recently resigned to accept appointment as sales manager for Mahl Equipment Co., the farm machinery manufacturing division of Standard Iron and Wire Works, Inc., Minneapolis, Minn.

Necrology

HAROLD WOODWARD DERRY, manager, new industries department, Pacific Power and Light Co., passed away in December, 1948, following an extended illness and hospitalization. He was born at Foxboro, Mass., in 1883 and had spent most of his life in the East and Midwest, before joining the Pacific Power and Light Co. in 1939. He was an electrical engineering graduate of Tufts College in 1907, and had been engaged in utility work throughout most of his professional career. After a long period of service in industrial sales with the Union Gas and Electric Co. of Cincinnati, and the Pennsylvania Power and Light Co. of Allentown, he served as consultant for the World Power Conference in 1936, and then became principal industrial engineer for the Tennessee Valley Authority. In the Pacific area he became interested in rural electrification and with the growth of ASAE activities in that region, became a member of the Society in 1946. He is listed in "Who's Who in Engineering" and was a member of Delta Upsilon fraternity and the Masonic Lodge. He is survived by his widow and a daughter in Portland, Ore., a son in New Kensington, Pa., and two grandchildren.

What the Agricultural Engineer, Rural Builder and Farmer Should Know About Douglas Fir Plywood

The proper selection of building materials for the farm is based on a number of considerations.

This is one of a series of advertisements describing these considerations as they apply to the selection and use of Douglas fir plywood for rural homes and farm buildings.

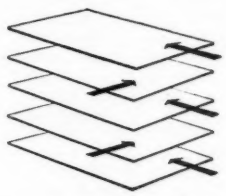
UNIT STRESS VALUES

Douglas fir plywood is so convenient to use that some of its other qualities may be overlooked. Any conventional material can be nailed to a braced frame as a "dead-weight" covering. But plywood's inherent strength contributes to the structural assembly and may permit reduction in framing. This is possible because Douglas fir's natural strength is utilized more efficiently when a plywood panel is manufactured.

WOOD CELL ARRANGEMENT

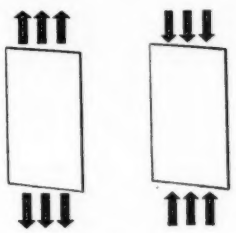
The Douglas fir grows by adding long, tapered cells in parallel arrangement, interlocked so that it is difficult to pull them apart lengthwise. A board cut from a fir log is very strong along the grain, not so strong across.

PLYWOOD PANEL CONSTRUCTION



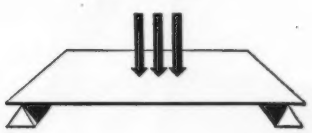
Thin veneers peeled from the log have these same strength characteristics. When assembled into plywood panels, with alternating grain direction, the strength becomes approximately equal both lengthwise and crosswise.

STRENGTH PROPERTIES TENSION... COMPRESSION



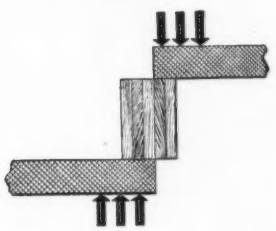
Basic stresses for Douglas fir recommended by the U. S. Forest Products Laboratory are 2000 lbs. per square inch tension along the grain, 1466 lbs. per square inch compression. When a plywood panel is subjected to tensile or compressive force, only those plys with grain running in the same direction as the force are considered. Computing this tensile strength requires only simple mathematics. For a ⅜" panel, assembled from three ⅛" plys, the combined cross-section area would be 2 (⅛") 12"= 3 square inches per foot of width. A panel 4 feet wide would carry a tensile load computed by multiplying the cross-sectional area by the basic tensile stress —3"x4'x2000=24,000 pounds. If the load were applied in the other direction, so that only the center ply grain paralleled the force and the entire 8 foot length of the panel acted, the total load would be the same—1 (⅛") 12"x8'x2000=24,000 pounds. Compression strengths are similarly computed.

FLEXURE



Bending a panel brings both tensile and compressive stresses into action. The ply on the outside of the curve is in tension, the one inside compressed. The same high strength characterizes this use of plywood.

SHEAR



Another type of stress is involved when the force is applied to one face panel and transmitted through the panel thickness. Here the glue line carries the load from one ply to another. Since the adhesives used in Douglas fir plywood are stronger than the wood itself, and the plys are at right angles, a "rolling shear" action develops. Wood fibers are literally rolled out of position rather than separated from the glue. The force required to effect this separation is relatively high.

ALLOWANCES FOR GRADE AND FOR DRY LOCATIONS

All veneers are not perfect, but are graded and assembled into panels according to quality. Thus the engineer-designer decreases the basic stress in his computation in relation to the grade of panel used. When plywood is to be used in locations where its moisture content will not exceed 16%, basic working stresses may be materially increased. For most farm applications, this limitation will be exceeded during certain seasons, but the use of Exterior panels assures the designer that the adhesive will hold and the panels retain the strength indicated in the unit stress computations.

Douglas Fir Plywood

LARGE, LIGHT, STRONG *Real Wood* Panels

AVAILABLE to agricultural engineers working on structural design applications of Douglas fir plywood — a copy of "Technical Data on Plywood." Write Douglas Fir Plywood Association, Tacoma Building, Tacoma 2, Washington.

Douglas Fir Plywood Association, Tacoma 2, Washington

In this spiral grain loader, the Stow Flexible Shaft transmits the power from the engine to a countershaft which connects to a V-Belt drive on top. The V-Belt drive revolves the auger-type elevator.

Simply designed, isn't it? That's because easily-installed Stow Flexible Shafting completely eliminates the need for bevel gearing, slip joints or other complicated parts. *And, just as important*—even if the angle of the Bazooka is constantly changing during the loading operation, the Stow Flexible Shaft delivers efficient, reliable drive . . . smooth, non-binding service.

STOW Flexible Shafting may solve YOUR problem of power transmission. It is made by the originator of the Flexible Shaft principle. Write to us today for more detailed information.

STOW MANUFACTURING CO.
39 Shear St. Binghamton, N. Y.

Registration and Ag Engineering Service

To the Editor:

CONGRATULATIONS on the continued attention in AGRICULTURAL ENGINEERING to the subject of registration of agricultural engineers. Here in Minnesota there is no agricultural engineering classification in the registration of professional engineers. There certainly is a need for registration. Right now in Minnesota there is a tremendous amount of land drainage being done, and needless to say the engineering work on some of it is of a standard that no person with even a smattering of engineering knowledge would tolerate. This type of work is just as expensive to the farmers as good work would be and is doomed to failure. It will give a black eye to drainage work in general here.

I was interested in the comment in the February ASAE Newsletter on agricultural engineering service. I am an agricultural engineer (graduate of Iowa State College in 1933) and have for some time seen the need for not only making this type of information available to farmers, but also in helping them to get the work done. So far I have my own drainage equipment and am hoping to get a building crew organized that will be able to carry out the plans which I prepare. It is very interesting and has been profitable.

ORDEAN E. OLSEN

Olsen Farm Service
Montevideo, Minnesota

Offers Publication Exchange

To the Editor:

AS AN interested reader of AGRICULTURAL ENGINEERING, it has occurred to me that I might be of assistance to a few of your readers.

In your list of "New Literature" there is often an English publication listed which is probably unobtainable on your side. If therefore any of your readers would care to write to me stating the details of the publication they require, I would be only too pleased to send it to them. By way of payment we could perhaps arrange an exchange of similar publications, so as to avoid any currency difficulties.

JOHN A. TURNEY

66, Melton Road,
Wellingsborough,
Northants, England

A-E Serves the Tourist and Resort Industry

(Continued from page 195)

As this educational program proceeds, it is becoming more and more evident that we are pioneering in a new field of education. For 30 years, the farmers of Michigan have been obtaining educational information on improved farming methods through the Extension Service of Michigan State College. No professional agency provides this information within as easy reach as the network of county agricultural agents.

Though it is one of our three leading industries in Michigan, the tourist and resort business has been without substantial professional assistance. Because of its importance to the public, it is imperative that past mistakes are not repeated in the development of new accommodations. It is hoped that through education, the architects, engineers, contractors, and builders, as well as the tourist operators themselves, will become better informed regarding some of the engineering and design essentials of developing facilities for tourists. The effect of such education, through published literature, meetings and visits in the field and on campus, county agents' offices, and correspondence is already being felt. We have record of some such service being rendered to over 2000 people during the last three years.

A tourist and resort exhibit is on display in the agricultural engineering building at Michigan State College. It occupies a space of 20 x 70 ft, and includes a full-size, one-room cottage completely furnished, as well as panels, models, and pieces of equipment showing desirable features for various types of resort facilities. The display will be open during the ASAE annual meeting at East Lansing, June 20 to 23. Additional information on the tourist and resort program will be available to all who are interested.

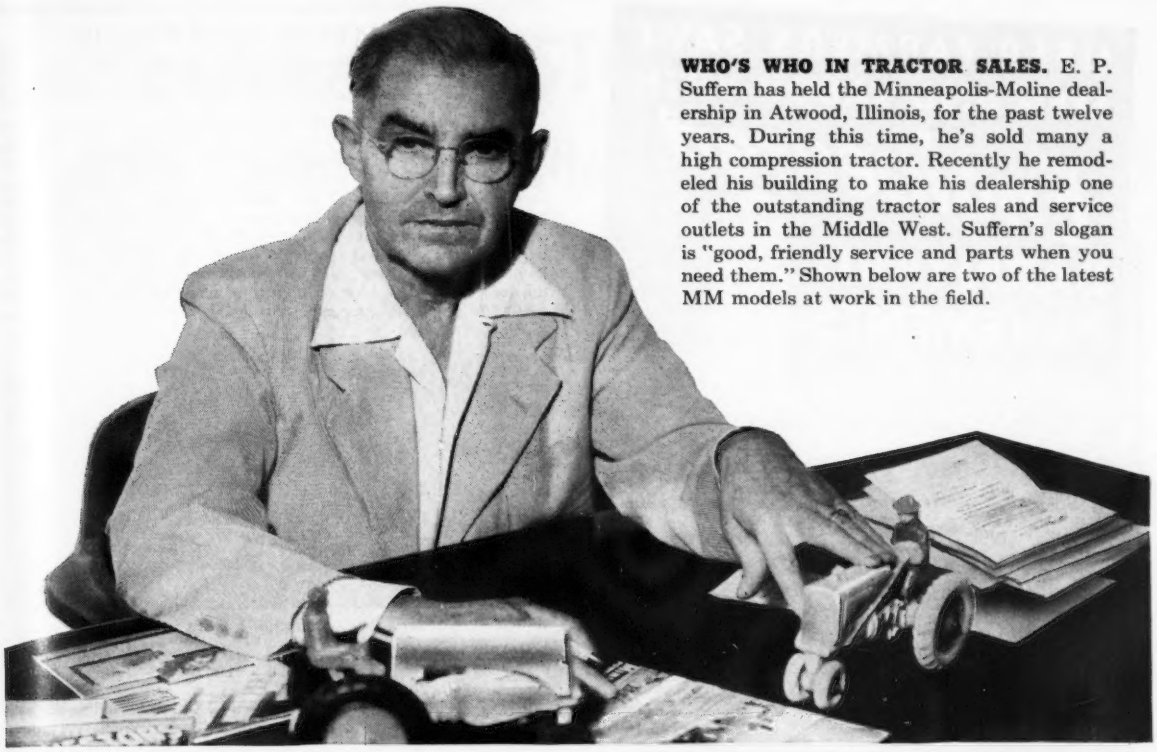
Standard Letter Symbols for Physics

NEW American Standard Letter Symbols for Physics finally approved by the American Standards Association, September 13, 1948, have been published by the American Society of Mechanical Engineers.

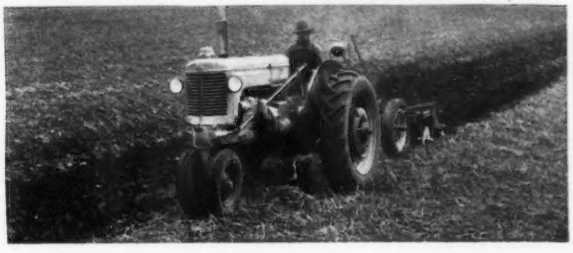
The new standard is indexed as ASA Z10.6-1948. It was prepared by the Sectional Committee on Letter Symbols and Abbreviations for Science and Industry. Sponsoring organizations include the ASCE, AIEE, ASEE, ASME, and AAAS. Members of Subcommittee 10 on Physics are active leaders in this field.

It is the hope of the sponsors that the standard will be developed to its full value by early and continued wide application in scientific and engineering practice.

The price of this standard is $1.00 per copy postpaid, and orders should be addressed to the American Society of Mechanical Engineers, 29 W. 39th St., New York 18, N. Y.



WHO'S WHO IN TRACTOR SALES. E. P. Suffern has held the Minneapolis-Moline dealership in Atwood, Illinois, for the past twelve years. During this time, he's sold many a high compression tractor. Recently he remodeled his building to make his dealership one of the outstanding tractor sales and service outlets in the Middle West. Suffern's slogan is "good, friendly service and parts when you need them." Shown below are two of the latest MM models at work in the field.



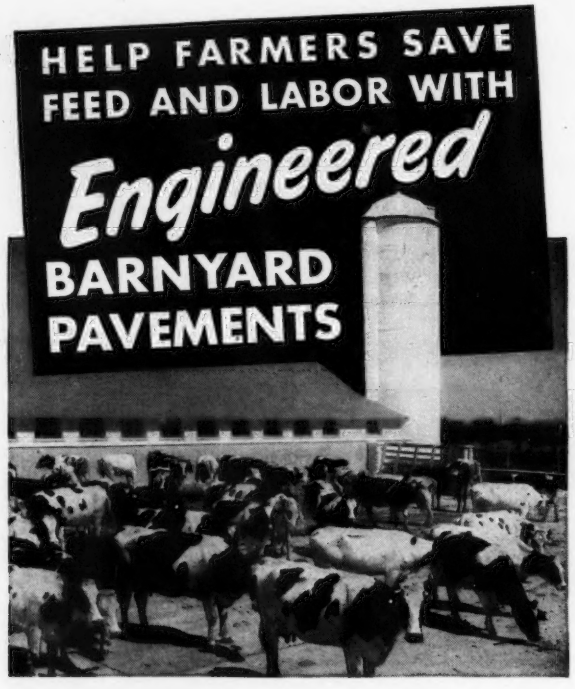
"I'm planning for bigger and better high compression sales in the future,"

says ***E. P. Suffern***
Minneapolis-Moline dealer of Atwood, Illinois

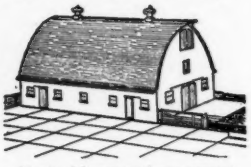
"Judging by the present trend to high compression, I believe that the tractor market is going to swing just about 100% to high compression within the next few years.

"Besides more power, our gasoline-operated Minneapolis-Molines offer easier starting, smoother idling, faster warm-up and cleaner burning of fuel. And once a farmer has enjoyed these advantages, why should he take less?"

You've got a good point there, Mr. Suffern. More and more farmers are learning about the flexibility and convenience of gasoline—they like the way gasoline-operated tractors cover more acres, finish work on time. That's why about eighty per cent of the tractors being manufactured today have high compression engines. *Ethyl Corporation.*



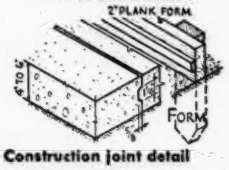
ONE of rural America's biggest problems is producing enough food at low cost to meet domestic and overseas needs. An improvement that will help attain this goal is a concrete-paved barnyard. It takes animals out of the mud and dust; helps keep them healthy. It saves work at milking time and results in a lower sediment test. It saves feed and manure.



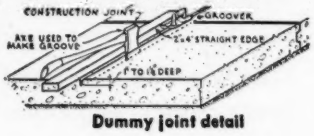
Typical barnyard pavement

A paved barnyard is more than a slab of concrete. It must be engineered for grade, thickness and service requirements. The sketches illustrate a few of the necessary details available to agricultural engineers. Write today for free, helpful "how to build" literature on many profitable, long-lasting concrete improvements. Literature distributed only in U. S. and Canada.

Expansion joints between slab and building



Construction joint detail



Dummy joint detail

PORTLAND CEMENT ASSOCIATION

Dept. A4-1, 33 W. Grand Ave., Chicago, Ill.

A national organization to improve and extend the uses of portland cement and concrete . . . through scientific research and engineering field work

NEWS FROM ADVERTISERS

New Products and Literature Announced by AGRICULTURAL ENGINEERING Advertisers

Low-Wheel Grain Drill (International Harvester), Model M, in the 28-6 (14-ft) size seeds 5½ acres of grain per hour. This new drill, available in various sizes, operates on 6:00x16 tires. It offers smooth, light-draft operation and accurately controlled depth on seedbeds. Bearings are pressure lubricated and sealed against dust. The new Model MF, similar to the M, has a large capacity divided hopper for fertilizer on one side and seed on the other. The fertilizer adjustment can be set to dispense 30 to 1,135 lb of commercial fertilizer to the acre. Both the Models M and MF will be available with fluted or double-run feed and with a selection of furrow openers. Both offer precision seeding of practically every size and kind of seed at increased working speeds in the field.

Deere Model "M" low-wheel grain drill

New John Deere Tractor. John Deere announces a new two-row companion (Model "MT") to the Model "M" one-row tractor. The "MT" has many features in common with the "M", including the same two-cylinder, valve-in-head engine, adjustable air-cushion seat, adjustable steering wheel, standing platform, electric starter, three-way power (drawbar, belt, power take-off), four forward speeds (1⅜ to 11 mph) and power to pull two 12-in plow bottoms, two-row bedder, 6-ft double action disk harrow, or a 7-ft tractor mower. The purchaser will have a choice of several types of front-wheel assemblies.

"Touch-o-matic" hydraulic control will regularly be furnished on the new tractor. This control is the same principle as used on the Model "M" except that there are two finger-tip control levers, one for each side of the tractor.

A full line of two-row "Quik-Tatch" bedding, planting, and cultivating tools will be built for the new tractor. One of these is a two-row stalk cutter with four sets of high-carbon reversible rotating blades for each row. They work close to the ground, shredding either wet or dry stalks and spreading the residue evenly on the field. Cutting height is controlled by power lift on the tractor.

New John Deere Model "MT" tractor pulling two-row stalk cutter

Massey-Harris Co. announces two new low-pressure, low-gallonage sprayers have just been added to the Massey-Harris line. The new machine is available in either of two models, the No. 2 which is a front-mounted sprayer, or the No. 3 which is a trailer type. The No. 2 mounted is adaptable to fit on any make of tractor, and has a powerful gear pump that is easily attached to the p-t-o shaft. The No. 3 has the same mechanical features but is mounted on a pull-behind trailer along with a 150-gal tank. Low pressure is used to avoid drift. All materials are corrosion resistant . . . the bronze and stainless steel gear pump has a built-in safety feature in its spring by-pass valve that will automatically open in the event the pressure exceeds 100 lb. It is impossible to damage any of the equipment *(Continued on page 204)*

Most popular ASBESTOS roof shingle Johns-Manville has ever developed!

It's a rigid asbestos strip

NEW AMERICAN COLONIAL DESIGN: Distinctively beautiful, wins instant approval. Has a slightly staggered horizontal shadow line and deep-grained texture. Available in several pleasing colors. Blends perfectly with any style of architecture.

Any carpenter can apply

SELF-ALIGNING, SELF-SPACING: You don't need chalk lines. Each strip covers a large area . . . speeds application. Only 80 pieces required per square . . . only 4 nails per shingle in pre-punched holes.

Permanent as stone

FIREPROOF, ROTPROOF, WEATHERPROOF: Made from two practically indestructible materials—asbestos and cement. Thousands of J-M asbestos shingles have been in service over 35 years. Not one has ever burned or worn out! No signs they won't last another 35 years or more!

American Colonials meet the construction standards of Industry-Engineered Homes

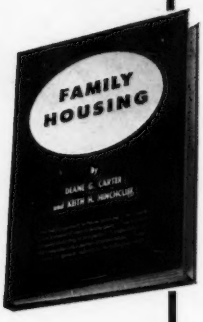
SEND FOR THIS FREE BROCHURE: It tells the full story of this outstanding development . . . shows many beautiful roofs in accurate full-color. Ask for brochure No. AS-85A. Address: Johns-Manville, Box 290, New York 16, New York.

JOHNS-MANVILLE JM PRODUCTS

Do You Know

the "inside and out" requirements for farmhouse construction . . . . urban homes . . . . remodeling?

FAMILY HOUSING



by
DEANE G. CARTER
and
KEITH H. HINCHCLIFF

Here is a new book that discusses the problem of housing specifically from the standpoint of function and *family needs*. In clear, understandable language, the authors cover every phase of home-building, taking account of the number in the family, its environment, its personality, and its income.

In an all-inclusive discussion on the construction of farmhouses, the authors analyze the reasons for variations in requirements for farmhouses. They draw comparisons between urban and farm houses, and discuss the problem of where to locate the farmhouse. Special farmhouse plan features and their advantages are included.

Important Features:

- **the house-planning approach**
- **a special consideration of remodeling**
- **a discussion of construction, materials, equipment, and costs**
- **a step-by-step discussion of building, buying, and financing**

March 1949 — 265 pages — College Edition, $3.00
May 1949 — Professional Edition, $4.00

EXAMINE THE BOOK WITHOUT COST

ON APPROVAL COUPON

JOHN WILEY & SONS, INC.
440 Fourth Ave., New York 16, N.Y.

Please send me, on 10 days' approval, a copy of Carter and Hinchcliff's FAMILY HOUSING. (☐ College Edition @ $3.00. ☐ Professional Edition @ $4.00.) If I decide to keep the book, I will remit price plus postage; otherwise, I will return the book postpaid.

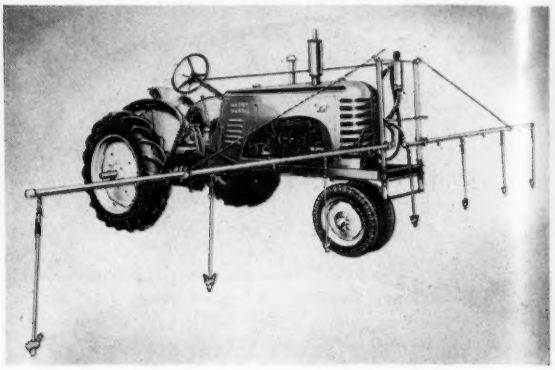
Name .....
Address .....
City ..... Zone ..... State .....
Employed by .....

(Offer not valid outside U.S.) AE-4-49

News from Advertisers

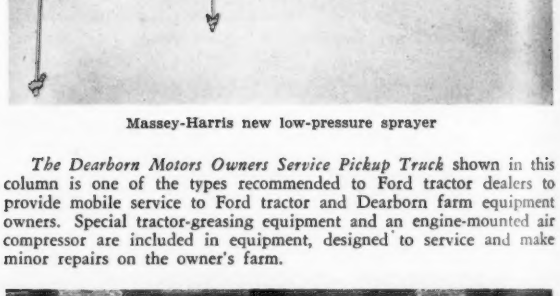
(Continued from page 202)

by excessive pressure. The lightweight, corrosion-resistant aluminum booms are specially treated for strength and toughness. Brass spray nozzles which have flat surfaces to easily and accurately align the spray pattern have an 80-mesh screen filter, and are mounted in brass bases that are permanently set in the booms. The booms are designed to swing back freely, and reposition themselves automatically, if they encounter an obstruction. An attachment is available which allows either boom to be individually raised or lowered for irregularities or fence obstructions and either or both booms may be shut off at any time. Boom height from the ground is adjustable to fit the crop or growth conditions.



Massey-Harris new low-pressure sprayer

The Dearborn Motors Owners Service Pickup Truck shown in this column is one of the types recommended to Ford tractor dealers to provide mobile service to Ford tractor and Dearborn farm equipment owners. Special tractor-greasing equipment and an engine-mounted air compressor are included in equipment, designed to service and make minor repairs on the owner's farm.



Dearborn Motors service truck

Heavy-Duty Tractor Mower for International Harvester Farmalls H and M, the model HM-24, is intended for continuous operation in large acreages of hay. It is a direct-connected, rear-mounted, V-belt, power-take-off-driven mower built throughout for heavy-duty service. The mower is available with 5, 6, or 7-ft cutter bar. The illustration is of the Model A-24 mower, mounted on Farmall Super A tractor, which is similar in design to the HM-24. The features include very sturdy construction, sturdy frame mounting, positive safety device, heavy-duty bearings, flywheel, drawbar, hinge pins, flywheel shaft, coupling bar, and double-lifting springs.

International Harvester heavy-duty tractor mower

Harvesting wheat—a Self-Propelled "Powerflow Drive" Harvestor

Strengthening the Basis of Our Economy...

The American standard of living is a tangible monument to the progress of free men. In no other country, in any age, have people enjoyed all the rights, privileges and benefits which we in this country now take for granted. We can point with pride to the accomplishments of this great nation, but we must also accept these rights and benefits as a responsibility that none of us can shirk without inviting trouble.

The industry and ingenuity, the cooperation and teamwork of American labor and management, the American system of free enterprise—these things made possible our present standard of living, which is the *envy* of the world.

These qualities, or attributes, of the American way of life are secure to us and our posterity only as long as we continue to exercise vigilantly and diligently our responsibilities in a democracy. Elsewhere in the world, these responsibilities would not be considered a disagreeable obligation but a welcomed privilege. The exercise of our franchise to vote . . . the willingness to do more than is expected . . . the cooperativeness to give ground at personal sacrifice for the common good of all mankind . . . the ingenuity to overcome apparently insurmountable obstacles—these are but practical applications of the golden rule which will secure the continuation of the blessings of our free enterprise system and democracy.

We have many obligations to discharge if we are to maintain the pace of progress and strengthen the basis of our economy. We must conserve our natural resources so that our children and our children's children will not face want, social unrest, and an uncertain future.

Food, clothing and shelter are derived from the soil. Without these products of the soil, the wheels of industry would cease to turn; business would suffer; the economic welfare of the nation would deteriorate; and unemployment with its bitter consequences would again haunt many American homes.

MM Builds Quality Modern Machines

Minneapolis-Moline takes pride in providing *quality* machines for agricultural America . . . machines planned and designed by Minneapolis-Moline engineers to equip progressive farmers to cut costs and to eliminate drudgery so that they may utilize the potential possibilities of modern methods of agriculture . . . more faithfully discharge their stewardship over one of our most important basic natural resources—our soil. To this end we rededicate our skill, our experience, our knowledge, our deep-rooted regard for quality. This we do with some pride, of course; but more so with the humble feeling that we are but fulfilling our responsibility to those we serve.

MINNEAPOLIS-MOLINE MODERN MACHINERY

MINNEAPOLIS-MOLINE MINNEAPOLIS 1, MINNESOTA

Seeding wheat with a Moline-Monitor Drill

Planting corn and fertilizing too

Cultivating checkrowed corn 4 rows at a time

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Beard, Joseph O., Jr. — Student, Virginia Polytechnic Institute, Blacksburg, Va. (Mail) Box 2658, Va. Tech. Sta.

Beasley, Harry E.—Extension cotton ginning specialist, Arkansas Extension Service, 421½ W. Capitol, Little Rock, Ark.

Bigalow, Ivan W. — Agricultural engineer, Cornell University. (Mail) Farm Bureau Office, New Hartford, N. Y.

Blomquist, Loyd E.—Agricultural engineer, California Packing Corp. (Mail) Wahiawa, Oahu, T. H.

Casado, G., Mario — Manager, Hacienda Carhuachi. (Mail) Calle Bolivar No. 19, Ciudad, Bolivar, Venezuela.

Castro, Fernando Suarez de—Agricultural engineer, National Federation of Coffee Growers of Colombia, Department Tecnico. (Mail) c/o Wm. X. Hull, Soil Conservation Service, USDA, Washington, D. C.

Derry, B. E.—Manager of sales and engineering, French & Hecht Div., Kelsey-Hayes Wheel Co., Davenport, Iowa.

Dunn, James D.—Agricultural engineer, Soil Conservation Service, USDA. (Mail) P. O. Box 373, Carrizo Springs, Tex.

Effa, John—Pumping and irrigation equipment, 1319 Foster Ave., Chicago, Ill.

Elbel, Oscar J.—Agricultural engineer, Soil Conservation Service, USDA. (Mail) P. O. Box 26, Crystal City, Tex.

Gibbs, Arthur E. — District sales manager, Cleveland Graphite Bronze Co. (Mail) 332 So. Michigan, Chicago 4, Ill.

Gram, R. H.—Supervisor of agricultural services, British Columbia Electric Railway Co., Ltd., 618 Columbia St., New Westminster, B. C., Canada.

Griffin, Jack G. — Student of agricultural engineering, Iowa State College, Ames, Iowa (Mail) 192 Pammel Court.

Handley, Robert C. — Agricultural engineer, Doane Agricultural Service, Inc., 5144 Delmar Blvd., St. Louis 8, Mo.

Jenkins, Leonard W. — Student, Virginia Polytechnic Institute, Blacksburg, Va. (Mail) Box 5549, Va. Tech. Station.

Jones J. Nick, Jr. — Student, Virginia Polytechnic Institute, Blacksburg, Va. (Mail) Box 5570, Va. Tech. Station.

Jones, Thomas E. — Student, Virginia Polytechnic Institute, Blacksburg, Va. (Mail) Box 4577, Va. Tech. Station.

Karath, Edward A. — Agricultural engineer, Soil Conservation Service, USDA. (Mail) Box 154, South Charleston, Ohio.

Kay, R. P. — Graduate student in agricultural engineering, University of Illinois, Urbana, Ill.

Keller, A. H. — Chief engineer, International Harvester Co., East Moline Works, East Moline, Ill.

Kirkpatrick, Mark H., Jr. — Agricultural engineer (research), Soil Conservation Service, USDA. (Mail) Box 697, Blacksburg, Va.

Linthicum, Benjamin, J. — Student, Virginia Polytechnic Institute, Blacksburg, Va. (Mail) 5657, Va. Tech. Station.

Lucas, William E., Jr. — Student, Virginia Polytechnic Institute, Blacksburg, Va. (Mail) Box A-374, Va. Tech. Station.

Mayeux, Mansel M. — Assistant extension agricultural engineer, Louisiana State University, University Station, Baton Rouge, La.

McCurry, James M. — Electrification advisor, Meriwhether-Lewis Electric Membership Cooperative, Centerville, Tenn. (Mail) Box 162.

McKay, B. B. — Student, Virginia Polytechnic Institute (Mail) Millwood, Va.

Michael, Victor C. — 427 Colson St., Gainesville, Fla.

Mitchell, Robert R. — Factory representative, Noble Cultivators (Mail) Lind, Wash.

Moffett, Frank H. — 215 Kaloramo St., Staunton, Va.

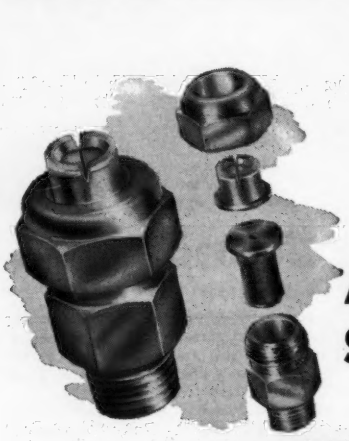
O'Harrow, C. T. — Assistant chief engineer, West Allis Works, Tractor Div., Allis-Chalmers Mfg. Co. (Mail) 2478 N. 7 St., Wauwatosa 13, Wis.

Rahlson, Erich A. — Mechanical engineer, Corn States Engineering Service, 422 Court, Des Moines, Iowa.

Rystrom, Raymond W., Jr. — Agricultural engineer, Soil Conservation Service, USDA (Mail) 1003 12th St., Marion, Iowa.

Sager, Fred M. — Assistant general line zone manager, International Harvester Co. (Mail) Box 1201, Stamford, Tex.

(Continued on page 208)



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AGRICULTURAL
SPRAY NOZZLES

YOUR GUARANTEE of TOP PERFORMANCE

● Specify Delavan agricultural nozzles to be sure your equipment performs at peak efficiency . . . the way you designed it!

New Delavan LS type flat spray nozzles are standard in size and feature a new design for maximum orifice protection, assuring longer life and better field performance.

Delavan nozzles are available in a wide range of types for herbicide and insecticide application; in ratings up to 100 gallons per acre.

Delavan nozzles offer you the benefit of years of research experience in the spray nozzle field. You can safely specify Delavan for any application where accuracy and precision are important.

Write for detailed information today. Our engineers will gladly assist with application data or quote to your specifications.

DELAVAN MANUFACTURING CO.
3009 SIXTH AVENUE
DES MOINES 13, IOWA

two ways to make your harvest hum

..Smoother ..Steadier!

Direct Drive Power Take-Off

Steps up the performance of PTO-driven machines. Driven directly from engine, independent of transmission clutch. Equipped with separate clutch, controlled by lever near tractor seat. No more breaks in PTO power by transmission clutch disengagement, gear shifting or travel stops. Standard equipment on the new Oliver tractor line at no extra cost.

Here's a new crop-saving combination to hustle along your harvest . . . profitably!

One . . . the compact, big-capacity Model 15 Grain Master. Its scoop-type header takes a full 6-foot swath. From sickle to cleaning sieve, the Model 15 is packed with improvements winnowed from 100 years of experience in building fine threshing machinery.

Number *two* . . . Oliver now offers a convenient Direct Drive Power Take-Off as standard tractor equipment. Coupled with the six forward speeds of the new 6-cylinder Oliver Row Crop "77", this modern Oliver advancement brings you greater combining efficiency and smoothness than you've ever before attained.

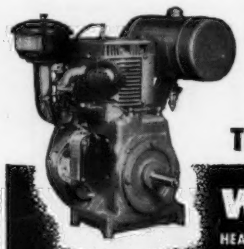
Stop at the sign of the Oliver shield soon and check the many *farm utility* features found in the new Oliver tractor fleet . . . and in Oliver harvesting equipment.

The OLIVER Corporation
400 West Madison Street, Chicago 6, Illinois

THE OLIVER CORPORATION

OLIVER

"FINEST IN FARM MACHINERY"



20% MORE H.P.
15% LESS WEIGHT
10% LOWER COST
That's the *new* MODEL AEN

WISCONSIN
HEAVY-DUTY *Air-Cooled* **ENGINE!**

Replacing the universally popular Wisconsin Model AEH Air-Cooled Engine, the new Model AEN turns up 7.5 H.P. at 3,000 R.P.M. as against 6.1 H.P. at 3,200 R.P.M. delivered by the engine it replaces. Weight: 110 lbs., as against 130 lbs. for the AEH. Price: approximately 10% lower.

All this has been accomplished without sacrificing heavy-duty crankshaft capacity or any of the traditional Wisconsin features such as: Tapered roller bearings at *both* ends of the drop-forged crankshaft; oil pump and spray lubrication; weather-sealed high tension outside magneto with impulse coupling for quick starting and dependable ignition in any climate, in any weather; flywheel-fan air-cooling — extremely efficient at all temperatures from sub-zero to 140°F.

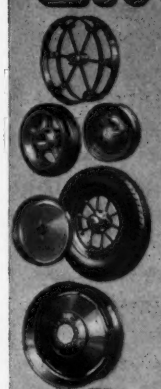
The Model AEN represents a major achievement in the design and construction of a light weight heavy-duty power unit for all-purpose power applications. Write for Bulletin S-109.

The Wisconsin line includes 4-cycle single cylinder, 2- and 4-cylinder models in a complete power range from 2 to 30 H.P.

MOST IN H.P. HOURS

WISCONSIN MOTOR CORPORATION
World's Largest Builders of Heavy Duty Air Cooled Engines
MILWAUKEE 14 WISCONSIN

EWC WHEELS



Designed to do the Job

For more than fifty years we have built dependable steel wheels for movable equipment . . . agricultural and industrial.

You can rely on EWC engineers to recommend the correct wheels for your unit. This is particularly valuable when new machines or new models are being considered.

If one of our standard wheels is not the most efficient, we can design and manufacture special wheels.

Write for our catalog

ELECTRIC WHEEL CO., 2908 Pine, Quincy, Ill.

Applicants for Membership

(Continued from page 206)

Sandahl, Everett M.—Partner, Lundberg & Sandahl Farm Equipment, Box 685, Dayton, Iowa.

Sanderson, Robert A.—Assistant agricultural engineer, Soil Conservation Service, USDA. (Mail) 604 S. Barnes St., Mason, Mich.

Savery, C. H. — In charge of production engineering, French and Hecht Div., Kelsey-Hayes Wheel Co., Davenport, Iowa.

Seeber, Harold S.—Assistant chief engineer, International Harvester Co., East Moline Works, East Moline, Ill.

Senn, James D.—Electrical development representative (rural) Tennessee Valley Authority. (Mail) 206 W. Moore St., Tuscumbia, Ala.

Shackelford, Charles T.—Student, Virginia Polytechnic Inst. (Mail) Lookout, W. Va.

Shelton, Curtis H.—Student, Virginia Polytechnic Inst., Blacksburg, Va. (Mail) Box 6219, Va. Tech. Station.

Slater, C. S. — Soil conservationist (research), Soil Conservation Service, USDA (Mail) Agricultural Research Center, Beltsville, Md.

Swailes, Earl J.—Chief engineer, American Conveyor Co. (Mail) 2055 Hawthorne Ave., Melrose Park, Ill.

Tullis, Harry E. — Engineer, Soil Conservation Service, USDA. (Mail) 417 E. Center, Pocatello, Ida.

Wangerin, LaRue W. — Research engineer, University of Wichita Foundation for Industrial Research, Wichita, Kans. (Mail) 741 S. Clifton.

Webber, H. G.—Webber Supply Co., Ulysses, Kans.

TRANSFER OF GRADE

Adams, William M., Jr.—Assistant materials handling engineer, International Harvester Co. (Mail) 207 S. 1st Ave., Carbon Cliff, Ill. (Junior Member to Member)

Patterson, Ralph E.—Instructor in agricultural engineering, Pennsylvania State College, Pa. (Mail) 524 N. Burrowes St. (Junior Member to Member)

Stoddard, Lowell — Manager of tractor and implement sales, E. J. Gilbreath Tractor Co., Albertville, Ala. (Mail) 317 Rose Rd. (Junior Member to Member)

New Literature

PUMP HANDBOOK, Volney C. Finch. Cloth V+202 pages, 5¼x8¾ Illustrated. National Press (Millbrae, Calif.) $4.00.

This work is devoted primarily to water supply pumps, but engineers will find it a convenient general reference to pumps and pumping, covering design types, selection to meet requirements, installation, operation, maintenance, and economy. There are separate chapters on centrifugal pumps, rotary pumps, reciprocating pumps, historical development of the centrifugal pump, theory of the centrifugal pump, elementary design formulas for centrifugal pumps, hydraulic balance and thrust bearings; capacity, head, power, and efficiency of centrifugal pumps; characteristic curves of a centrifugal pump; suction lifts, cavitation, and specific speed; the affiinity laws, volute casings and diffusion vanes, materials for pumping various liquids, installation and operation of centrifugal pumps, pump priming, boiler feed pumps, propeller pumps, mixed-flow pumps, peripheral pumps, deep well turbine pumps, farm water supply systems, and testing. An appendix gives extensive tabular and graphical data on pumps and pumping requirements.

LIGHT FOR SEEING ON THE FARM. Paper, 14 pages, 8½ x 11 inches. Illustrated. Edison Electric Institute (420 Lexington Ave., New York 17, N. Y.), and Better Light Better Sight Bureau. $10 per 100, or $95 per 1000. Back cover blank for local imprinting. Clearly presents elementary information on light and sight, with particular emphasis on the use of electric lights to make farm work easier and to enable farmers to do a better job with fewer accidents.

New Federal and State Bulletins

Your Modern Farm Kitchen, by Morris Whiteman, Bulletin 241 of the Rural Housing Advisory Committee for British Columbia (404 West Hastings St., Vancouver, B. C.). This is a 36-page, 6x9-inch bulletin on kitchen arrangements and equipment. It follows a 1948 bulletin by the Committee on "Repairs to the Farm Home." Agricultural engineers are represented on the committee by J. R. W. Young and J. E. Beamish, both members of ASAE.

Every Day Jamesway SAVES 3 HOURS of Back-Breaking Work!

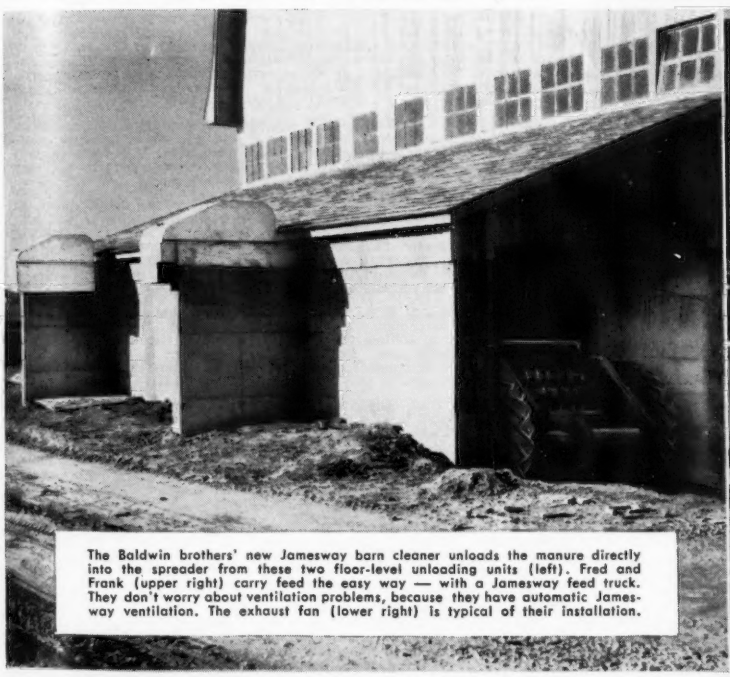
say Fred, Frank, and Robert Baldwin, Brooklyn, Wisconsin

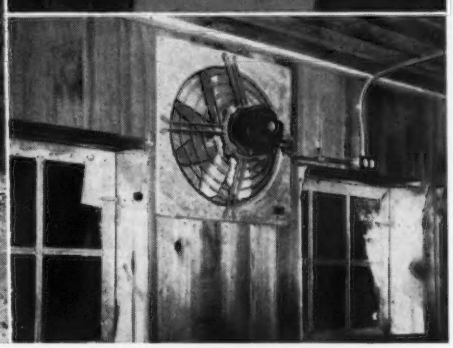
It's true! The Baldwin brothers have cut their chores 3 hours a day. And at the same time they've stepped up their milking herd from 41 to 60 cows. A miracle? No. Just Jamesway barn planning and equipment.

"Our old barn was too crowded, too cold, too damp, too dark. It took too much work and wasted too much time," says Fred Baldwin.

"Then we remodelled with Jamesway plans and built an addition. We put in Jamesway stalls, water bowls, feed trucks, windows, ventilators and a Jamesway barn cleaner. We've cut out the back-breaking drudgery — 3 hours of it. We have more time to enjoy living. Last year we bought and sold 800 dairy cattle and maintained a milking herd of 60."

Now is the time for you, too, to modernize with Jamesway! Take the back-breaking work out of your chores. Boost your farm output . . . save time and money with Jamesway equipment. See your Jamesway dealer today. For literature, write branch office nearest you.

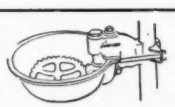




The Baldwin brothers' new Jamesway barn cleaner unloads the manure directly into the spreader from these two floor-level unloading units (left). Fred and Frank (upper right) carry feed the easy way — with a Jamesway feed truck. They don't worry about ventilation problems, because they have automatic Jamesway ventilation. The exhaust fan (lower right) is typical of their installation.

✓ Check this Jamesway Chart to see how much time you can save

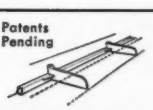
☐ Save up to 10 minutes a day with Jamesway ventilation.



☐ Save up to 30 minutes a day with Jamesway water cups.

☐ Save up to 40 minutes a day with Jamesway feed truck.

Patents Pending



☐ Save 1 hour or more a day with Jamesway barn cleaner.

YOUR Jamesway EQUIPMENT & HOUSING MORE MILK EGGS MEAT DEALER

The World's Largest Manufacturer of Barn and Poultry Equipment

James Mfg. Co.

Ft. Atkinson, Wis.
Elmira, N. Y.
Los Angeles, Calif.

STOP! Don't throw those old AUTO TIRES away

A GREAT NEW IDEA

Here's a 15" diameter IMPLEMENT WHEEL that takes discarded automobile tires — high pressure 5.50, 6.00 and 6.50. Dealers note. Farmers note.

100955
5" BOLT—5½" BOLT CIRCLE
15 x 5" K WHEEL

and STANDARD
1⅜" SAE 1045 COLD
ROLLED CENTERLESS
GROUND SPINDLES

IMMEDIATE DELIVERY

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Wheel Builders Since 1888

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over 9,200 exhibitors from France and abroad

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Special Sections: Agricultural Engineering, Farm Implements and Materials

INFORMATION

French Chamber of Commerce of the United States
630 Fifth Avenue • New York 20, N.Y.

Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. The Society does not investigate or guarantee the representations made by parties listed. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request. "Agricultural Engineer" as used in these listings, is not intended to imply any specific level of proficiency, or registration, or license as a professional engineer.

NOTE: In this Bulletin the following listings still current and previously reported are not repeated in detail. For further information see the issue of AGRICULTURAL ENGINEERING indicated.

POSITIONS OPEN: 1948. APRIL—O-615. JULY—O-627, 630. SEPTEMBER—O-641. NOVEMBER — O-652. 1949. JANUARY—O-654, 655. FEBRUARY—O-656, 657, 658. MARCH—O-659, 660, 661, 662, 663, 664, 665.

POSITIONS WANTED: 1948. MARCH—W-146,. APRIL—W-158. AUGUST—W-184, 189. NOVEMBER—W-196, 197, 199, 202, 203, 204. DECEMBER—W-206, 208, 209. 1949. JANUARY—W-211, 212, 213, 215, 216. FEBRUARY—W-217, 218, 219, 220, 221, 222, 223, 224, 225. MARCH—W-227, 228, 229, 230, 231, 232, 233, 234 235, 236.

NEW POSITIONS WANTED

AGRICULTURAL ENGINEER desires design, research, or sales work in farm structures or soil and water field with private company. BS deg in agricultural engineering expected in June, University of Tennessee. Farm background and experience with all types of farm machinery. Machine shop experience 2 yr. War service 29 mo, with Corps of Engineers. No disability. Available June 5. Married. Age 26. Salary $3000-3600. W-219

AGRICULTURAL ENGINEER desires design, development, extension, management, sales, or teaching in rural electric or soil and water field. BS deg in agricultural engineering, 1949, University of Maine. Experience in hardware stockroom, dairy, surveying, road construction, and as a proctor at the University of Maine, with supervision of 25-30 students. War service in infantry. No disability. Available immediately. Single. Age 25. Salary open. W-237

AGRICULTURAL ENGINEER desires design, development, research, extension, or project engineering work in soil and water or farm structures field. BS deg in agricultural engineering 1948, University of Tennessee. Farm background. Instructor in veterans on-farm training, 8 mo. Available July 1. Single. Age 22. Salary open. W-238

AGRICULTURAL ENGINEER desires development, management, or research work in farm structures, soil and water, or power and machinery field, in industry. BS deg in agricultural engineering, University of Missouri, expected June 1949. Farm work in summer vacations and work with Soil Conservation Service about one year. War service in Army Air Force. No disability. Available July 1. Single (to be married in June). Age 22. Salary open. W-239

AGRICULTURAL ENGINEER desires design and development work in power and machinery field, with manufacturer. Any location. BS deg in agricultural engineering, University of Saskatchewan, expected in 1949. Farm background. Experience two summers in welding and operating heavy machinery. War non-commissioned service in RCAF, 2 yr. No disability. Available May 1. Single. Age 24. Salary open. W-240

AGRICULTURAL ENGINEER desires sales, research, or service work in power and machinery field, in industry. BS deg in agriculture, with major in agricultural engineering expected in June, Rutgers University. Farm background. Some experience in building trades and as an inspector for an electrical instrument manufacturer. War commissioned service, 4 yr in Marine Corps, with duty as fighter pilot and instructor. No disability. Available August 1. Married. Age 28. Salary open. W-241

AGRICULTURAL ENGINEER desires design, development, extension, management, research, service, or teaching work in power and machinery, farm structures, or rural electric field. BS deg in agricultural engineering, 1948, University of Tennessee. War enlisted and commissioned service, 4 yr. No disability. Available now. Married. Salary open. W-242

AGRICULTURAL ENGINEER desires development, management, research, or teaching work in power and machinery or soil and water field, in industry. BS deg in agriculture and in agricultural engineering expected June 1949, Ohio State University. Farm background. Experience in tool design, sales, and plant engineering. War enlisted service nearly 3 yr as ordnance optical instrument repairman. No disability. Available July 1. Married. Age 28. Salary open. W-243

AGRICULTURAL ENGINEER desires design, development, extension, management, sales, service, or teaching work in any field, with college or industry. BS deg in agricultural engineering expected in June, Pennsylvania State College. Farm background. Acetylene welder one year with aircraft manufacturer. Combination welder 3 years in Air Force. One summer as construction welder. One summer inspector of highway construction. General office work 1½ yr. War service 3 yr, Army Air Corps. No disability. Available June 15. Married. Age 27. Salary open. W-244

AGRICULTURAL ENGINEER desires design, development, management, research, or teaching in soil and water field. Prefer location in Southwest. BS deg in agricultural engineering, Oklahoma A and M College, 1948. MS deg in agricultural engineering, with major in irrigation and drainage expected in August, Utah State Agricultural College. Surveyor on defense plan construction, one year. Graduate teaching assistant one year. War service as cryptographer, 3 yr, Army Air Force. No disability. Available September 1. Married. Age 27. Salary $3600-4000. W-245

(Continued on page 212)

We have the capacity to Manufacture Farm Implements!

We have complete metal working facilities and the technical "know-how" to produce a wide variety of farm implements. If you have a new item, contact us and find out how we may help you get into production quickly. Or, if you have an established item it's very possible we can show you how to produce it more efficiently.

We assemble completely or partially, then ship to you or drop-ship to your customers. Why not send us your blue prints and we will give you a firm quotation and a definite delivery schedule. Our facilities are Sheet Metal Fabricating —20 gauge to 1/4" Plate, Machine Shop, Metal Spinning and Finishing to 14 gauge.

WRITE FOR CATALOG

This literature shows you our equipment and also pictures a number of the items we have produced.

IN THE HUB of Industry!

Cincinnati Metalcrafts Inc.

Division C

5000 Brotherton Road, Cincinnati 9, Ohio

Phone: REdwood 2214

Rural Electric Engineers and Students

YOU know, all too well, how much damage is done to motors, lamps, heating devices, other appliances, also switches and outlets, during thunderstorms. Most of this destruction follows high-frequency, high-voltage surges induced in wires between transformer and appliance by lightning within a radius of three miles.

Obviously, the ideal way to nullify such surges is by appropriate capacity properly located. The trick is to get a capacitor that will stand up indefinitely. The Green Guard Lightning Arrester embodies a capacitor so well built and well proved that it is guaranteed for five years against failure from any cause. It should serve for a life-time.

Green Guard was developed by a rural electric service engineer. Selling and installing it is a "natural" for such engineers, also for students who want worthy, remunerative vacation work. We invite you to write for full information about Green Guard, the opportunity it offers, the responsibility of our company, and its 77 years of experience in lightning protection.

R. D. Bienemann
Security Mfg. & Contracting Co.
Burlington :: Wisconsin

GRADUATE ENGINEERS
5-15 Years' Experience

Midwest Farm Tractor Manufacturer needs experienced engineers qualified for research and design on farm tractors —diesel and gasoline engines, chassis and hydraulic components. Our personnel know of these openings.

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Midwest Mfr., care of "Agricultural Engineering",
St. Joseph, Michigan

PROFESSIONAL DIRECTORY

OLSON MANAGEMENT SERVICE

Drainage and Erosion Control Engineering, Structure Design, Farm Architectural Service, Work Simplification Studies, Product Application Engineering, Management, Soil Surveys, and Testing.

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FRANK J. ZINK ASSOCIATES
Agricultural Engineers

Consultants on product development, designs, research, market research, public relations

FELLOW A.S.A.E. MEMBER S.A.E. Telephone: Harrison 7-0723 Suite 4300, Board of Trade Bldg. Chicago 4, Illinois

RATES: Announcements under the heading "Professional Directory" in AGRICULTURAL ENGINEERING will be inserted at the flat rate of $1.00 per line per issue; 50 cents per line to A.S.A.E. members. Minimum charge, four-line basis. Uniform style setup. Copy must be received by first of month of publication.

PERSONNEL SERVICE BULLETIN

(Continued from page 210)

AGRICULTURAL ENGINEER desires development, extension, research, or teaching in power and machinery field. Prefer location in corn belt. BS deg in agriculture, March 1949; BS deg in agricultural engineering expected in June, Ohio State University. Background in dairy and general farming. Experience in operating and servicing power machinery. Enlisted and commissioned war service in Army Air Corps, 2 yr. No disability. Available July 1. Married. Age 23. Salary open. W-246

AGRICULTURAL ENGINEER desires design and development work in power and machinery field with manufacturer. Prefer Midwest location. Studied chemical engineering 3½ yr, University of Detroit. Apprentice, detailer, and designer of tools and dies, 2 yr. Design of production machines 1½ yr. Design and development of farm tractors and implements 2⅓ yr. Enlisted and commissioned war service, U S Army, 2⅓ yr. No disability. Available now. Married. Age 28. Salary $435 per mo. W-247

AGRICULTURAL ENGINEER desires design, development, or research work in soil and water field, especially in hydraulics, hydrology, or electrical geophysics, with experiment station or private consultant, in temperate climate location. BS deg in agricultural engineering, University of Nebraska, 1939. Certificate in radio, electronics, and microwaves, University of Chicago, 1943. Experience in research in USDA, as utilization engineer in REA, and in project engineering and research in SCS. War enlisted service in Signal Corps, 29 mo. Currently employed in P-2 position, but hold P-3 rating in civil service register. No disability. Available on reasonable notice. Single. Age 39. Salary, equal to P-3 scale. W-248

New Literature

RURAL ELECTRIFICATION (fourth edition), J. P. Schaenzer. Cloth, VIII+338 pages, 6x9 inches. Illustrated and indexed. Bruce Publishing Co. (Milwaukee, Wis.) $3.76.

This text and reference for the help of vocational agriculture teachers and others has been brought up to date by changes and additions to reflect progress in this field since publication of the third edition in 1940. Its 30 chapters cover electricity, the silent partner, how electricity is made and distributed, serving the farmer, wiring materials, wiring maintenance and repair, wiring the farmstead, wiring the home, wiring the barn and outbuildings, lights and lighting, electric motors, fractional-horsepower motor applications, ensilage cutters, feed grinders, wood sawing, hay hoisting and mow curing, farm water supply, electric power for irrigation, poultry-house lighting, electric poultry equipment, the pig brooder, the milking machine and cream separator, dairy refrigeration, other electrical equipment for the dairy, the barn cleaner and silo unloader, the electric fence, the electric hotbed, sweet potato curing and storage, home and farm freezers, laundry and cleaning equipment, and kitchen and household equipment. An appendix lists applications of electricity for the home and farm.

PEST CONTROL HANDBOOK (8th edition), by W. E. Ripper et al. Paper, 79 pages, 5 x 8 inches. Illustrated and indexed. Pest Control, Ltd. (Cambridge, England). One shilling.

Facilities, recommendations, and procedures of the publisher, a custom spraying organization operating in the United Kingdom and elsewhere from home bases in England. Considerable space is devoted to specific pests, classified under the crops concerned.